FIFTY-SIXTH ANNUAL REPORT

OF THE

SECRETARY

OF THE

STATE BOARD OF AGRICULTURE

OF THE

STATE OF MICHIGAN

AND

THIRTIETH ANNUAL REPORT

OF THE

EXPERIMENT STATION

FROM

JULY 1, 1916, TO JUNE 30, 1917

BY AUTHORITY

LANSING, MICHIGAN
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1917

REPORT OF THE SECRETARY.

OF THE

STATE BOARD OF AGRICULTURE

East Lansing, Mich., *July 1, 1917.*

To Hon. Albert E. Sleeper,

Governor of the State of Michigan:

Sir—I have the honor to submit to you herewith, as required by law, the accompanying report for the fiscal year ending June 30, 1917, with supplementary papers.

Very respectfully,

ADDISON M. BROWN,

Secretary of the State Board of Agriculture.

STATE BOARD OF AGRICULTURE

	Term expires.
ROBERT D. GRAHAM, Grand Rapids	1st Monday January, 1920
CHAIRMAN OF THE BOARD.	
ALFRED J. DOHERTY, Clare	1st Monday January, 1920
WILLIAM H. WALLACE, Saginaw	1st Monday January, 1922
I. ROY WATERBURY, Detroit	1st Monday January, 1922
JOHN W. BEAUMONT, Detroit	1st Monday January, 1924
JASON WOODMAN, Paw Paw	1st Monday January, 1924
FRED L. KEELER, SUPT. OF PUBLIC INSTRUCTION	*Ex-Officio*
FRANK S. KEDZIE, PRESIDENT OF THE COLLEGE	*Ex-Officio*

ADDISON M. BROWN, East Lansing, Secretary.
BENJAMIN F. DAVIS, Lansing, Treasurer.

STANDING COMMITTEES.

DIVISIONS OF AGRICULTURE AND OF VETERINARY SCIENCE	I. R. Waterbury, R. D. Graham.
DIVISION OF ENGINEERING	A. J. Doherty, J. W. Beaumont.
DIVISION OF HOME ECONOMICS	Jason Woodman, I. R. Waterbury.
DIVISION OF SCIENCE AND LETTERS	J. W. Beaumont, W. H. Wallace.
EXPERIMENT STATION	W. H. Wallace, A. J. Doherty.
EMPLOYEES	R. D. Graham, J. W. Beaumont.
FINANCE	R. D. Graham, W. H. Wallace.
COLLEGE EXTENSION DIVISION	A. J. Doherty, Jason Woodman.
BUILDINGS AND COLLEGE PROPERTY	I. R. Waterbury, Jason Woodman.

MICHIGAN AGRICULTURAL COLLEGE

(Under control of the State Board of Agriculture.)

FACULTY AND OTHER OFFICERS.

Frank S. Kedzie, M. S., D. Sc., President, [a] [b] Sept. 15, '80; [c] Sept. 15, '16.

Jonathan L. Snyder, A. M., Ph. D., LL. D., President Emeritus; [a] [b] Feb. 22, '96; [c] Sept. 15, '16.

William J. Beal, Ph. D., D. Sc., D. Agr., Emeritus Professor of Botany; [a] [b] June 9, '70; [c] June 15, '10.

Wilbur O. Hedrick, M. S., Ph. D., Professor of Economics; [a] [b] Aug. 24, '91; [c] June 13, '16.

Herman K. Vedder, C. E., Professor of Civil Engineering; [a] [b] Sept. 15, '91; [c] July 7, '09.

Walter B. Barrows, B. S., Professor of Zoology and Physiology; Curator of the General Museum; [a] [b] [c] Feb. 15, '94.

Rufus H. Pettit, B. S., in Agr., Professor of Entomology; [a] Jan. 1, '97; [b] [c] Sept. 1, '06.

Addison M. Brown, A. B., Secretary of the College; [a] [b] [c] June 1, '02.

Robert S. Shaw, B. S. A., Dean of Agriculture; [a] [b] Sept. 1, '02; [c] Jan. 15, '08.

Elida Yakeley, Registrar; [a] July 15, '03; [b] [c] June 1, '08.

Arthur R. Sawyer, B. S., E. E., Professor of Electrical Engineering; [a] [b] April 11, '04; [c] June 13, '16.

A. Crosby Anderson, B. S., Professor of Dairy Husbandry; [a] Sept. 1, '05; [b] June 10, '09; [c] June 15. '10.

Edward H. Ryder, M. A., M. Pd., Professor of History; Director of Summer School; [a] [b] Sept. 1, '05; [c] Apr. 28, '16.

Arthur J. Clark, A. B., Professor of Chemistry; [a] [b] Sept. 1, '06; [c] Apr. 28, '16.

Joseph A. Polson, B. S., M. E., Professor of Mechanical Engineering; [a] [b] Sept. 1, '06; [c] June 13, '16.

George W. Bissell, M. E., Dean of Engineering; [a] [b] June 18, '07; [c] June 13, '16.

Ward Giltner, D. V. M., M. S., Professor of Bacteriology and Hygiene: [a] [b] July 1, '08; [c] June 16, '15.

Harry J. Eustace, B. S., M. H., Professor of Horticulture; [a] [b] [c] Aug. 15, '08.

Walter H. French, M. Pd., M. S., Professor of Agricultural Education: [a] [b] [c] Sept. 1, '08.

*Vernon M. Shoesmith, B. S., Professor of Farm Crops; [a] [b] [c] Feb. 14, '09.

Ernst A. Bessey, Ph. D., Professor of Botany; [a] [b] [c] June 15, '10.

Richard P. Lyman, B. S., D. V. M., Dean of Veterinary Science; Professor of Veterinary Medicine; [a] [b] [c] Sept. 28, '10.

William W. Johnston, A. M., Professor of English Literature and Modern Languages; [a] [b] [c] Sept. 1, '12.

Louis C. Plant, Ph. B., M. S., Professor of Mathematics; [a] [b] [c] Sept. 1, '13.

Georgia L. White, Ph. D., Dean of Home Economics; [a] [b] [c] April 1, '14.

Merris M. McCool, Ph. D., Professor of Soils; [a] [b] [c] July 15, '14.

Alfred K. Chittenden, M. F., Professor of Forestry; [a] [b] [c] July 15, '14.

Mary E. Edmonds, B. S., Professor of Domestic Science; [a] [b] [c] Sept. 15, '15.

Robert K. Steward, B. S., C. E., Professor of Drawing and Design; [a] [b] [c] Sept. 1, '16.

¶Capt. Ira Longanecker, Professor of Military Science and Tactics; [a] [b] [c] Feb. 1, '16.

Chace Newman, Associate Professor of Drawing; [a] Sept. 1, '97; [b] Sept 1. '07; [c] June 13, '16.

Frank H. Sanford, B. S., M. F., Associate Professor of Forestry; [a] [b] Dec. 1, '06; [c] May 1, '09.

Charles W. Chapman, A. B., B. S., Associate Professor of Physics; [a] Jan. 1, '07; [b] Sept. 1, '11; [c] June 13, '16.

Charles P. Halligan, B. S., Associate Professor of Horticulture; [a] [b] Apr. 8, '07; [c] June 11, '13.

Mrs. Lillian L. Peppard, Associate Professor of Domestic Art; [a] [b] Sept. 1, '08; [c] June 13, '16.

George A. Brown, B. S., Associate Professor of Animal Husbandry; [a] [b] Sept. 1, '08; [c] July 21, '15.

Richard deZeeuw, Ph. D., Associate Professor of Botany; [a] [b] Sept. 1, '09; [c] July 21, '15.

Harry H. Musselman, B. S., Associate Professor of Farm Mechanics; [a] [b] Sept. 1, '09; [c] July 21, '15.

Frank W. Chamberlain, B. S., D. V. M., Associate Professor of Comparative Anatomy; [a] [b] Jan. 1, '11; [c] July 21, '15.

Cyrus A. Melick, D. C. E., Associate Professor of Civil Engineering; [a] [b] Sept. 1, '11; [c] July 13, '16.

Ralph C. Huston, M. S., Ph. D., Associate Professor of Chemistry; [a] [b] Sept. 1, '11; [c] July 21, '15.

Elam T. Hallman, D. V. M., Associate Professor of Animal Pathology; [a] [b] Sept. 1, '12; [c] July 21, '15.

Charles H. Burgess, B. A., Associate Professor of Poultry Husbandry; [a] [b] Oct. 1, '13; [c] June 13, '16.

Joseph F. Cox, B. S. in Agr., Associate Professor of Farm Crops; [a] [b] Dec. 1, '13; [c] Mar. 28, '17.

Thomas Gunson, Assistant Professor of Horticulture and Superintendent of the Grounds; [a] [b] Apr. 1, '91; [c] June 13, '16.

E. Sylvester King, Assistant Professor of Public Speaking; [a] Jan. 1, '00; [b] Sept. 1, '02; [c] June 10, '14.

L. Zae Northrup, B. S., A. M., M. H. E., Assistant Professor of Bacteriology and Hygiene; [a] [b] Sept. 1, '07; [c] June 11, '13.

George D. Shafer, Ph. D., Assistant Professor of Entomology; [a] July 1, '08; [b] Sept. 1, '08; [c] July 19, '16.

William E. Laycock, A. B., Assistant Professor of Physics; [a] [b] Sept. 1, '08; [c] Oct. 18, '16.

Benjamin B. Roseboom, Jr., B. S., Assistant Professor of Physiology; [a] [b] Jan. 15, '09; [c] June 10, '14.

MAURICE F. JOHNSON, B. S., C. E., Assistant Professor of Mathematics; [a,b] April 1, '09; [c] June 11, '13.

FREDERICK A. BURT, B. S., Assistant Professor of Geology; [a,b] Sept. 1, '09; [c] June 10, '14.

°LLOYD C. EMMONS, B. S., A. B., Assistant Professor of Mathematics; [a,b] Sept. 1, '09; [c] June 11, '13.

CHARLES H. SPURWAY, B. S., M. A., Assistant Professor of Soil Physics; [a,b,c] Sept. 1, '09.

OREN L. SNOW, B. S., Assistant Professor of Physics; [a,b] Sept. 1, '10; [c] Oct 18, '16.

ERNST G. FISCHER, Ph. B., Assistant Professor of German; [a] Sept. 1, '10; [b,c] Sept. 1, '14.

W. IRVING GILSON, B. S., M. F., Assistant Professor of Forestry; [a,b] Jan. 1, '11; [c] June 13, '16.

*JOHN S. McDANIEL, B. S., D. V. M., Assistant Professor of Veterinary Medicine and Pharmacology; [a,b] Sept. 1, '11; [c] Feb. 28, '13.

BRUCE E. HARTSUCH, A. B., Assistant Professor of Chemistry; [a,b] Sept. 1, '11; [c] June 16, '15.

CHARLES S. DUNFORD, M. A., Assistant Professor of Economics; [a,b] Sept. 1, '11; [c] June 16, '15.

*JOHN P. HUTTON, D. V. M., Assistant Professor of Veterinary Surgery; [a,b] Sept. 1, '12; [c] June 1, '13.

MERTON M. CORY, B. S., E. E., Assistant Professor of Electrical Engineering; [a,b] Sept. 1, '12; [c] July 21, '15.

CHARLES B. MITCHELL, M. A., Assistant Professor of Public Speaking; [a,b] Sept. 1, '12; [c] June 16, '15.

CARL E. NEWLANDER, B. S., Assistant Professor of Dairy Husbandry; [a,b] Sept. 1, '12; [c] June 13, '16.

ALLEN C. CONGER, B. S., M. A., Assistant Professor of Zoology; [a,b] Sept. 1, '12; [c] June 13, '16.

*HOMER E. DENNISON, B. S., Assistant Professor of Dairy Husbandry; [a,b] Sept. 1, '12; [c] June 13, '16.

CLAUDE M. CADE, B. S., C. E., Assistant Professor of Civil Engineering; [a,b] Sept. 1, '13; [c] June 13, '16.

LESLIE H. COOLEDGE, B. S., A. M., Assistant Professor of Bacteriology; [a,b] Sept. 1, '13; [c] June 13, '16.

REN G. SAXTON, C. E., Assistant Professor of Civil Engineering; [a,b] Sept. 1, '13; [c] July 21, '15.

ELIJAH L. GROVER, B. S., Assistant Professor of Agricultural Education; [a,b] Sept. 1, '13; [c] June 13, '16.

HENRY T. DARLINGTON, M. S., Assistant Professor of Botany; [a,b,c] July 15, '14.

WM. P. WOOD, A. B., Ch. E., Assistant Professor of Chemistry; [a,b] Sept. 1, '14; [c] June 13, '16.

HERBERT A. GEHRING, C. E., Assistant Professor of Civil Engineering; [a,b,c] Sept. 1, '15.

CHARLES E. MILLAR, M. S., Assistant Professor of Soils; [a,b,c] Nov. 17, '15.

LAWRENCE N. FIELD, B. M. E., Assistant Professor of Mechanical Engineering; [a,b,c] Feb. 1, '16.

WALTER E. REULING, B. S., M. E., Assistant Professor of Mechanical Engineering; [a,b,c] Sept. 20, '16.

*LIEUT. MAX S. MURRAY, Assistant Professor of Military Science; [a,b,c] Sept. 20, '16.

JAMES W. BENNER, D. V. M., Assistant Professor of Pharmacology; [a,b,c] Jan. 10, '17.

JOHN I. HANDLEY, D. V. M., B. S. A., M. S., Assistant Professor of Surgery; [a,b,c] Jan. 10, '17.

INSTRUCTORS AND OTHERS.

The names of instructors whose resignations took effect between June 30th and Sept 1st, 1914, do not appear below.

*CAROLINE HOLT, Instructor in Drawing; [a,b,c] Sept. 1, '98.

LOUISE FREYHOFER, B. S., Instructor in Music; [a,b,c] Sept. 1, '02.

NORMA L. GILCHRIST, A. B., Instructor in English; [a,b,c] Sept. 1, '05.

FRANK A. SPRAGG, M. S., Instructor in Farm Crops; [a,b] Dec. 1, '06; [c] Sept. 1, '13.

MRS. MINNIE A. W. HENDRICK, A. B., Instructor in History; [a] Sept. 1, '07; [b,c] Sept. 1, '08.

ROSE M. TAYLOR, A. B., M. A., Instructor in Botany; [a,b,c] Feb. 8,' 08.

MRS. ANTOINETTE C. ROBSON, A. B., Instructor in Modern Languages; [a,b,c] Jan. 1, '09.

ANDREW WATT, Instructor in Forge; [a,b] April 1, '09; [c] Sept. 1, '16.

STANLEY E. CROWE, B. A., Instructor in Mathematics; [a,b,c] Sept. 1, '09.

RICHARD H. REECE, B. S., Instructor in Mathematics; [a,b,c] Jan. 1, '10.

DEWEY A. SEELEY, B. S., Instructor in Meteorology; [a,b,c] Mar. 16, '10.

EUGENIA I MCDANIEL, A. B., Instructor in Entomology; [a,b,c] Apr. 1, '10.

SERGT. PATRICK J. CROSS, Instructor in Military Science and Tactics; [a,b,c] May 1, '10.

BERTHA E. THOMPSON, A. B., M. A., Instructor in Botany; [a,b,c] Sept. 1, '10.

LOUIS B. MAYNE, A. B., Instructor in English; [a,b,c] Sept. 1, '10.

JAMES L. MORSE, B. S., Instructor in Mechanical Engineering; [a,b,c] Sept. 1, '10.

GEORGE H. COONS, A. M., Ph. D., Instructor in Plant Pathology; [a,b,c] Jan. 1, '11.

EDITH W. CASHO, Instructor in Physical Culture; Assistant to the Dean; [a,b] Sept. 1, '11; [c] June 16, '15.

RUFUS P. HIBBARD, Ph. D., Instructor in Plant Physiology; [a,b,c] Sept. 1, '11.

MABEL L. LEFFLER, Mus. B., Instructor in Music; [a,b,c] Sept. 1, '12.

GUY G. SPEEKER, B. S., A. M., Instructor in Mathematics; [a,b,c] Sept. 1, '12.

VERNE E. LEROY, A. B., M. S., Instructor in Zoology; [a,b,c] Sept. 1, '12.

WILLIAM M. WIBLE, A. M., Instructor in Mathematics; [a,b,c] Oct. 1, '12.

*FRANK E. MILLEN, B Sc. A., Instructor in Bee-keeping; [a,b,c] Sept. 1, '13.

JUDSON Q. OWEN, A. B., Instructor in English; [a,b,c] Sept. 1, '13.

*GROVER C. WOODIN, B. S. A., Instructor in Entomology; [a,b,c] Sept. 1, '13.

ROBERT E. LOREE, B. S., Instructor in Horticulture; [a,b,c] Sept. 1, '13.

*MYRON B. CHAPIN, Instructor in Drawing; [a,b,c] Sept. 1, '13.

EARL C. KIEFER, B. S., Instructor in Mathematics; [a,b,c] Sept. 1, '13.

WARREN W. HITCHCOCK, B. S., C. E., Instructor in Civil Engineering; [a,b,c] Sept. 1, '13.

DWIGHT T. EWING, B. S., Instructor in Chemistry; [a,b,c] Jan. 1, '14.

WESLEY E. EASTMAN, B. S., Instructor in Zoology; [a,b,c] Jan. 1, '14.

Alfred Iddles, B. S., Instructor in Drawing; a b c Apr. 1, '14.
Edward F. Woodcock, B. S., M. A., Instructor in Botany; a b c Sept. 1, '14.
Walter A. Reinert, B. S. in C. E., Instructor in Mathematics; a b c Sept. 1, '14.
Louise I. Clemens, B. S., Instructor in Domestic Science; a b c Sept. 1, '14.
*Walter L. Kulp, A. B., M. S., Instructor in Bacteriology; a b c Sept. 1, '14.
George M. Grantham, B. S., Instructor in Soils; a b c Sept. 1, '14.
Agnes V. Hatch, B. S., Instructor in Domestic Art; a b c Sept. 1, '14.
Frank D. Messenger, B. S., Instructor in Drawing and Design; a b c Sept. 1, '14.
Burt K. Philp, C. E., Instructor in Civil Engineering; a b c Sept. 1, '14.
William E. J. Edwards, B. S. A., Instructor in Animal Husbandry; a b c Sept. 1, '14.
*William D. Meltzer, B. S., Instructor in Dairy Manufactures; a b c Sept. 1, '14.
Dwight C. Carpenter, B. S., Instructor in Chemistry; a b c Sept. 1, '14.
Alison Ransford, Instructor in Cheese Making; a b c Jan. 1, '15.
John E. Burnett, B. S., Instructor in Dairy Husbandry; a b c June 16, '15.
Don B. Whelan, M. S., Instructor in Entomology; a b c July 1, '15.
Henry L. Publow, B. S., Instructor in Chemistry; a b c Sept. 1, '15.
Joseph W. Stack, B. S., Instructor in Zoology; a b c Sept. 1, '15.
Arthur L. Bibbins, B. S., Instructor in Farm Crops; a b c Sept. 1, '15.
Charles D. Ball, B. S., Instructor in Chemistry; a b c Sept. 1, '15.
Leo C. Hughes, A. M., Instructor in French and German; a b c Sept. 1, '15.
Kenneth G. Hancher, M. S., Instructor in Chemistry; a b c Sept. 1, '15.
Theodore E. Friedemann, B. S., Instructor in Chemistry; a b c Sept. 1, '15.
*William N. Clark, B. S. in Agr., Instructor in Animal Husbandry; a b c Sept. 1, '15.
James B. Hasselman, B. S., Instructor in English; a b c Sept. 1, '15.
Zella E. Bigelow, Instructor in Domestic Art; a b c Sept. 1, '15.
*Wendell A. Melton, B. S., Instructor in Physics; a b c Sept. 1, '15.
Paul L. Miller, M. A., Instructor in Economics; a b c Sept. 1, '15.
*Jesse F. Francis, B. S. A., Instructor in Poultry Husbandry; a b c July 21, '15.
Edna M. Garvin, B. S., Instructor in Domestic Science; a b c Oct. 5, '15.
Earle H. Stewart, B. S. in M. E., Instructor in Drawing; a b c Jan. 1, '16.
Stanard G. Bergquist, A. B., Instructor in Zoology; a b c Jan. 27, '16.
Frederick L. Abel, Director of the Band, Chorus and Glee Club; a b c Sept. 1, '16.
Ethel P. VanWagenen, B. A., Instructor in Domestic Science; a b c Sept. 1, '16.
Emma Francis, B. S., Instructor in Domestic Science; a b c Sept. 1, '16.
Homer M. Ward, B. S., Instructor in Civil Engineering; a b c Sept. 1, '16.
Roscoe H. Bush, B. S., Instructor in Mechanical Engineering; a b c Sept. 1, '16.
Royal G. Bigelow, B. S., Instructor in Mechanical Engineering; a b c Sept. 1, '16.

CHARLES G. NOBLES, B. S., Instructor in Bacteriology; [a b c] Sept. 1, '16.
HARRY C. YOUNG, M. S., Instructor in Botany; [a b c] Sept. 1, '16.
PERRY S. BRUNDAGE, B. S., Instructor in Chemistry; [a b c] Sept. 1, '16.
EDWARD L. UNDERWOOD, B. S., Instructor in Chemistry; [a b c] Sept. 1, '16.
JOHN D. MACMILLAN, A. M., Instructor in English; [a b c] Sept. 1, '16.
RAY B. WEAVER, A. M., Instructor in English; [a b c] Sept. 1, '16.
VERN JAMES, A. M., Instructor in Mathematics; [a b c] Sept. 1, '16.
ROYCE W. WYANT, B. S., Instructor in Dairy Manufactures; [a b c] Sept. 1, '16.
ARTHUR S. BURKETT, A. B., J. D., Instructor in Public Speaking; [a b c] Sept. 1, '16.
*LISA OSTERHOLM, B. S., Instructor in Domestic Art; [a b c] Sept. 1, '16.
*MAE M. PERSON, A. M., Instructor in History; [a b c] Sept. 1, '16.
AARON F. HEAD, B. S., M. S., Instructor in Soils; [a b c] Sept. 1, '16.
*WILLIAM H. TULLY, B. S., Instructor in Poultry Husbandry; [a b c] Oct. 1, '16.
JAMES P. COYLE, M. A., Instructor in Physics; [a b c] Oct. 1, '16.
GRACE F. SMILEY, B. S., Instructor in Domestic Art; [a b c] Jan. 1, '17.
BENJAMIN F. KINDIG, Instructor in Apiculture and State Bee Inspector; [a b c] Jan. 1, '17.
WILSON DUNCAN, Instructor in Farm Mechanics; [a b c] Jan. 1, '17.
*BERNARD A. KNOWLES, B. S., Instructor in Poultry Husbandry; [a b c] Jan. 1, '17.
FREDERICK W. FABIAN, B. S., Instructor in Bacteriology; [a b c] Jan. 1, '17.
SANDER STARK, B. S., Instructor in Physics; [a b c] Jan. 15, '17.
PERCY B. WILTBERGER, M. S., Instructor in Entomology; [a b c] Apr. 1, '17.
FRED HAGADORN, B. S., Instructor in Dairy Manufactures; [a b c] Apr. 1, '17.
EMMET O. EDSON, B. S., Instructor in Poultry Husbandry; [a b c] June 1, '17.
LINDA E. LANDON, Librarian; [a b c] Aug. 24, '91.
LORY F. NEWELL, Engineer; [a b c] Jan. 1, '98.
BENJAMIN A. FAUNCE, Clerk to the President; [a] Sept. 1, '99; [b c] Apr. 1, '10.
ROWENA KETCHUM, Nurse in charge of College Hospital; [a b c] Sept. 1, '00.
EDWYN A. BOWD, College Architect; [a] Jan. 1, '02; [b c] Nov. 5, '13.
*LENA M. MAXWELL, Assistant Cashier and Bookkeeper; [a] July 1, '02; [b c] Aug. 1, '12.
ANDREW P. KRENTEL, Foreman of the Pattern Shop; [a b c] Sept. 1, '02.
JACOB SCHEPERS, Cashier; [a b] May 1, '07; [c] July 1, '07.
RALPH S. HUDSON, B. S., Farm Foreman; [a b c] Dec. 1, '07.
MAUD A. MEECH, Chief Clerk to the Secretary; [a b] Apr. 1, '08; [c] Sept. 1, '10.
EDWARD C. CRAWFORD, Shop Engineer; [a b c] July 1, '09.
LOUISE E. WALSWORTH, Clerk to the Secretary; [a b c] Jan. 17, '10.
ERNEST A. EVANS, Foreman of the Machine Shop; [a b c] Sept. 1, '10.
WARREN S. ROBBINS, B. S., Assistant in Pathology; [a b] April 1, '11; [c] July 21, '15.
ELIZABETH M. PALM, Assistant Librarian; [a b c] July 15, '11.
BLANCHE A. BIRCHARD, Clerk to the President; [a b c] Aug. 10, '11.
CHARLES D. BETTS, Purchasing Agent; [a b c] Sept. 1, '11.
BERTHA A. HOLLISTER, A. B., State Seed Analyst; [a b c] Sept. 1, '13.
GEORGE H. PETERS, Assistant in Pattern Shop; [a b c] Oct. 1, '13.

JACOB A. EICHER, Foreman of the Foundry; [a b c] Sept. 1, '14.
CHARLES S. LANGDON, B. S., Alumni Secretary; [a b c] Sept. 1, '14.
ANNA L. FERLE, Assistant Registrar; [a b c] Oct. 1, '14.
J. J. HENDRYX, Foreman Forest Nursery; [a b c] March 15, '15.
EILEEN FLETCHER, Clerk to the Secretary; [a b c] June 15, '15.
MRS. NANCY L. EASTMAN, Matron College Residence; [a b] Sept. 1, '15; [c] Sept. 1, '16.
DON C. HEFFLEY, B. S., In charge of Student Employment Bureau and Secretary of Y. M. C. A.; [a b c] Sept. 1, '15.
PAUL C. KITCHIN, B. Sc., Graduate Assistant in Botany; [a b] Nov. 1, '15; [c] Jan. 1, '16.
SAMUEL TOMS, Assistant in Farm Mechanics; [a b c] Nov. 1, '15.
EUGENE WOOD, Assistant in Pattern Shop; [a b c] Jan. 1, '16.
LOUISE J. MERTES, Assistant State Seed Analyst; [a b c] Feb. 1, '16.
EDA H. TRICKEY, Clerk to Secretary; [a b c] April 5, '16.
LLOYD R. JONES, B. S., Graduate Assistant in Bacteriology; [a b c] July 1, '16.
LAWRENCE C. WHEETING, B. S., Graduate Assistant in Soils; [a b c] July 1, '16.
HENRICK J. STAFSETH, B. S., Graduate Assistant in Bacteriology; [a b c] Sept. 1, '15.
GROSVENOR W. PUTNAM, B. S., Graduate Assistant in Farm Crops; [a b c] Sept. 1, '16.
ROSE COLEMAN, Assistant in Library; [a b c] Sept. 1, '16.
FLORENCE STOLL, Graduate Assistant in Home Economics; [a b c] Sept. 1, '16.
MRS. MINNIE MEEKER, Matron College Cottage; [a b c] Sept. 1, '16.
FRIEDRIKA M. HEYL, House Mother Women's Building; [a b c] Sept. 1, '16.
CLARA HUNT, House Director Women's Building; [a b c] Sept. 1, '16.
JOHN GRENNAN, Foreman Forge Shop; [a b c] Sept. 1, '16.
JAMES A. BERRY, B. S., Graduate Assistant Bacteriology; [a b c] Sept. 1, '16.
WALTER K. MAKEMSON, B. S., Graduate Assistant in Botany; [a b c] Sept. 1, '16.
*EDGAR G. HAMLIN, B. S., Graduate Assistant in Forestry; [a b c] Sept. 1, '16.
LOUIS P. HOPPHAN, Assistant in Wood Shop; [a b c] Oct. 1, '16.
ROBERT MACKIE, Herdsman; [a b c] Jan. 1, '17.
H. DONALD HOOTMAN, Foreman Orchards; [a b c] March 28, '17.

EXPERIMENT STATION WORKERS.

ANDREW J. PATTEN, B. S., Chemist; [a b c] Sept. 1, '05.
CHARLES W. BROWN, B. S., Research Assistant in Bacteriology; [a b c] Aug. 1, '06.
°CHARLES S. ROBINSON, M. S., Research Assistant in Chemistry; [a b c] Sept. 1, '09.
MYRA V. BOGUE, Bulletin Clerk; [a b c] Jan. 1, '10.
ORRIN B. WINTER, A. B., Assistant in Chemistry; [a] Feb. 15, '10; [b c] Sept. 1, '13.
GEORGE J. BOUYOUCOS, Ph. D., Research Assistant in Soils; [a] June 16, '11; [b c] Sept. 1, '14.

J. Frank Morgan, M. A., Research Assistant in Bacteriology; [a b c] Sept. 1, '13.
Walter C. Dutton, B. S., Assistant in Horticulture; [a b c] Sept. 1, '13.
Fred. T. Riddell, B. S., Assistant in Dairying; [a b c] Sept. 1, '13.
Jay H. Muncie, B. A., Assistant in Plant Pathology; [a b c] Nov. 17, '13.
Elroy J. Miller, M. S., Assistant in Chemistry; [a b c] Sept. 1, '15.
Eugene F. Berger, B. S., Assistant in Chemistry; [a b c] Sept. 1, '15.
Arthur C. Lytle, B. S., Assistant in Dairying; [a b c] Nov. 1, '15.
Hans J. Bock, M. S., Research Assistant in Horticulture; [a b c] Jan. 1, '16.
*Allen E. Smoll, A. B., Assistant in Chemistry; [a b c] Jan. 1, '16.
Frank F. Hebard, B. S., Inspector; [a b c] Feb. 1, '16.
Carl F. Barnum, B. S., Inspector; [a b c] Feb. 10, '16.
Eugene E. Down, B. S., Assistant in Farm Crops; [a b c] April 1, '16.
Stanley J. Brownell, B. S., Assistant in Dairying; [a b c] Sept. 1, '16.
I. Forest Huddleson, B. S., M. S., Research Assistant in Bacteriology; [a b c] Sept. 1, '16.
*Edward A. DeWindt, B. Ch. E., Assistant in Chemistry; [a b c] Sept. 1, '16.
Ralph W. Peterson, B. S., Investigator in Seed Production; [a b c] Jan. 1, '17.

° Absent on leave.
* Resigned.
¶ Called to Army service.
a First appointment.
b Present appointment.
c present title.

AGRICULTURAL EXPERIMENT STATION

OF THE

MICHIGAN AGRICULTURAL COLLEGE

(Under the control of the State Board of Agriculture.)

STATION COUNCIL

FRANK S. KEDZIE, M. S., D. Sc., President *Ex-officio*.
ROBERT S. SHAW, B. S. A., Director.
WARD GILTNER, D. V. M., M. S., Bacteriologist.
°HARRY J. EUSTACE, B. S., M. H., Horticulturist and Vice Director.
ALFRED K. CHITTENDEN, M. F., Forester.
A. CROSBY ANDERSON, B. S., Dairy Husbandman.
RUFUS H. PETTIT, B. S. A., Entomologist.
ANDREW J. PATTEN, B. S., - Chemist.
MERRIS M. MCCOOL, Ph. D., Soil Physicist.
ERNST A. BESSEY, Ph. D., - Botanist.
*VERNON M. SHOESMITH, B. S., Farm Crops Experimenter.

ADDISON M. BROWN, Secretary.

ADVISORY AND ASSISTANT STAFF

CHARLES P. HALLIGAN, B. S., Asso. Horticulturist.
GEORGE A. BROWN, B. S., Asso. Animal Husbandman.
GEORGE D. SHAFER, Ph. D., Asso. Entomologist.
HARRY H. MUSSELMAN, B. S., Asso. in Farm Mechanics.
CHARLES H. BURGESS, A. B., Asso. Poultry Husbandman.
RUFUS P. HIBBARD, Ph. D., Research Asso. in Plant Physiology.
GEORGE H. COONS, Ph. D., Research Asso. in Plant Pathology.
FRANK A. SPRAGG, M. S., - Research Asso. in Farm Crops (Plant Breeding.)
°CHARLES S. ROBINSON, A. B., M. S., Research Asso. in Chemistry.
GEORGE J. BOUYOUCOS, Ph. D., Research Asso. in Soils.
ELROY J. MILLER, M. S., Research Asst. in Chemistry.
CHARLES W. BROWN, B. S., Research Asst. in Bacteriology.
HANS J. BOCK, M. S., Research Asst. in Horticulture.
JAMES F. MORGAN, M. A., Research Asst. in Bacteriology.
ORRIN B. WINTER, A. B., Research Asst. in Chemistry.
LESLIE H. COOLEDGE, A. M., Research Asst. in Bacteriology.
L. ZAE NORTHRUP, B. S., A. M., Asst. Bacteriologist.
EUGENE F. BERGER, B. S., Asst. in Chemistry.
*ALLEN E. SMOLL, A. B., Asst. in Chemistry.
EDWARD A. DEWINDT, B. Ch. E., Asst. in Chemistry.
EUGENIA I. MCDANIEL, A. B., Asst. in Entomology.
WALTER C. DUTTON, B. S., Asst. in Horticulture.
JAY H. MUNCIE, B. A., Asst. in Plant Pathology.
*GROVER C. WOODIN, B. S. A., Asst. in Entomology.

Eugene E. Down, B. S., Asst. in Farm Crops.
Arthur C. Lytle, B. S., Asst. in Dairying.
Stanley J. Brownell, B. S., Asst. in Dairying.
Fred T. Riddell, B. S., Asst. in Dairying.
Ralph W. Peterson, B. S., Asst. in Horticulture.
Raymond Nelson, B. S., Graduate Asst. in Botany.
Herdis L. Lewis, B. S., Graduate Asst. in Botany.
Carl F. Barnum, B. S., Feeds and Fertilizer Inspector.
Frank F. Hebard, B. S., Feeds and Fertilizer Inspector.
Linda E. Landon, - - Librarian.
Myra V. Bogue, - - Bulletin Clerk.

°Absent on leave. *Resigned.

STANDING COMMITTEE IN CHARGE.

William H. Wallace - - - - - - - - - - Saginaw.
Alfred J. Doherty - - - - - - - - - - Clare.

STATE WEATHER SERVICE.

(Under the control of the State Board of Agriculture.)

OFFICER OF THE SERVICE.

Director, - - - - - - C. F. Schneider, U. S. Weather Service.

COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS

Michigan Agricultural College and United States Department of Agriculture Cooperating

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ADMINISTRATION

Frank Stewart Kedzie, M. S., D. Sc., President.
Robert James Baldwin, B. S., Director of Extension Work.

EXTENSION SPECIALISTS

Representing the several Departments of the College

William Franklin Raven.............Ext. Representative in Upper Peninsula.
*Ivan Karl Maystead, B. S.............Ext. Specialist in Farm Crops.
John Whitley Nicolson, B. S............Ext. Specialist in Farm Crops.
John Henry Carmody, B. S.............Ext. Specialist in Horticulture.
Clarence William Waid, B. S...........Ext. Specialist in Potatoes and Vegetables.
*Charles Philo Reed, M. Agr...........Ext. Farm Management Demonstrator.
Paulina Elona Raven, M. S.............Ext. Specialist in Home Economics.
Margaret M. Justin, B. S..............Ext. Specialist in Home Economics.
Orsel Edwin Robey, B. S..............Ext. Specialist in Household Engineering.
Don Bion Whelan, M. S...............Ext. Specialist in Control of Insect Pests.
James Aaron Waldron, B. S.............Ext. Specialist in Live Stock.
*John Allen Petrie, B. S..............Ext. Specialist in Horticulture.
Edna Viola Smith, B. S.................Assistant in Home Economics.
Edmund Carl Mandenberg, B. S.........Ext. Specialist in Forestry.
Clara King Morris, B. S...............Assistant in Home Economics.
Ezra Levin, B. S......................Special Worker in Muck Land Crops.

COUNTY AGRICULTURAL AGENTS

Eben Mumford, Ph. D..........................State Leader.
Charles Benjamin Cook, B. S....................Assistant to State Leader.
James Wade Weston, B. S.......................Assistant to State Leader, U. P.
Roy Gabriel Hoopingarner, B. S.................Iron.
Earl Paul Robinson, B. S.......................Saginaw.
Harvey George Smith, B. S. A...................Kent.
Jason Woodman, B. S...........................Kalamazoo.
Claude Lawrence Nash, B. S....................Branch.
Harry B. Blandford............................Newaygo.
Leo M. Geismar...............................Houghton.
George E. Piper, B. S.........................Wexford.

*Resigned.

James Frank Kadonsky, B. S.	Gogebic.
John Martin Wendt, B. S.	St. Joseph.
Clark Louis Brody, B. S.	St. Clair.
Lee Roy Walker, B. S.	Marquette.
Clinton Vede Ballard, B. S.	Dickinson.
Curtis Linden Coffeen, B. S.	Lenawee.
Roswell Gilbert Carr, B. S.	Ontonagon.
Carl Henry Knopf, B. S.	Cheboygan.
Deloy Lesly Hagerman, B. S.	Ottawa.
Leslie Olds	Muskegon.
Russell Vaughan Tanner, B. S.	Mason.
Theodore Austin Farrand	Van Buren.
David Woodman	Alpena.
Alfred Bentall	Allegan.
Harry J. Lurkins	Berrien.
Frank Sandhammer, B. S.	Manistee.
Elton Brainard Hill, B. S.	Menominee.
Edward Glenn Amos, B. S.	Schoolcraft.

BOYS' AND GIRLS' CLUB WORK

Eduard Christian Lindemann, B. S.	State Agent.
Chester Augustus Spaulding, B. S.	Assistant.
Anna Bryant Cowles, B. S.	Assistant.

MARKETS

James Nathan McBride	Director.
Ralph Henry Elsworth, A. M.	Assistant.

FARMERS' INSTITUTES

Levi Rawson Taft, M. S.	Superintendent.

ACCOUNTS OF

THE MICHIGAN AGRICULTURAL COLLEGE

FOR THE YEAR ENDING JUNE 30, 1917

SECRETARY'S FINANCIAL REPORT

			Dr.	Cr.
July 1, 1916.	Cash on hand		$1,179 25	
July 1, 1916.	Cash on deposit, College Treasurer		36,464 63	
June 30, 1917.	To special appropriation receipts		459,043 11	
	From State Treasurer	$277,000 00		
	From U. S. Treasurer	73,059 35		
	From gifts, R. E. Olds	90,000 00		
	From institution and other sources	18,983 76		
June 30, 1917.	By disbursements			$436,830 36
	Special appropriations	$289,775 95		
	Experiment Station	65,974 21		
	Extension	81,080 20		
June 30, 1917.	To current account receipts		710,911 66	
	From State Treasurer, land grant interest	$69,437 43		
	From State Treasurer, one-fifth mill tax $560,000 00 (a) 166,000 00	394,000 00		
	From U. S. Treasurer, Morrill Fund	50,000 00		
	From institution and other sources	192,695 05		
	From South Haven Experiment Station	170 77		
	From U. P. Experiment Station	4,608 41		
	By general account disbursements			706,273 76
June 30, 1917.	By cash on hand			1,156 84
June 30, 1917.	By cash on deposit			63,337 69
			$1,207,598.65	$1,207,598 65

(a) Appropriated for Extension	$41,000 00
Appropriated for Experiment Station	15,000 00
Appropriated for Engineering Shops	55,000 00
Appropriated for Hall of Engineering	55,000 00

TABLE NO. 1.—*Tabular Exhibit of Secretary's report.*

	Balance sheet, July 1, 1916.		Transactions July 1, 1916, to June 30, 1917.		Balance sheet, June 30, 1917.	
	Dr.	Cr.	Dr.	Cr.	Dr.	Cr.
Cash	$1,179 25		$22.41		$1,156 84	
*College Treasurer	36,464 63			$26,873 06	63,337 69	
Special appropriation		$23,765 26	312,718 28	289,775 95		$48,428 11
Currents accounts		11,428 52	710,911 66	706,273 76		16,066 42
Experiment station		5,157 97	62,127 43	65,974 21		
Extension	2,707 87		84,197 40	81,080 20		
Totals	$40,351 75	$40,351 75	$1,169,977 18	$1,169,977 18	$64,494 53	$64,494 53

*Treasurer's statement is greater July 1, 1916, by $29,169.71 and June 30, 1917, by $20,639.43; warrants outstanding.

TREASURER'S ACCOUNT.

	Dr.	Cr.
Balance on hand July 1, 1916	$65,634 34	
Receipts from State Treasurer, and Secretary of College	1,168,690 03	
Interest on deposits during year	1,287 15	
Warrants paid July 1, 1916, to June 30, 1917	....	$1,151,634 40
Balance on hand June 30, 1917	....	83,977 12
Total	$1,235,611 52	$1,235,611 52

TABLE NO. 12.—*Statement of special appropriation accounts for the fiscal year ending June 30, 1917.*

	Balance of accounts, July 1, 1916.		Receipts during fiscal year.		Total available.	Total expended.	Balance of accounts, June 30, 1917.	
	Dr.	Cr.	From State Treasurer.	From institution and other sources.			Dr.	Cr.
Engineering shops	$5,949 00	....	$55,000 00	....	$49,051 00	$49,051 00	....	....
Experiment Station	....	$5,157 97	a45,000 00	$17,127 43	67,285 40	65,974 21	....	$1,311 19
Extension	2,707 87	....	b84,059 35	138 05	81,489 53	81,080 20	....	409 33
Gymnasium	....	23,936 42	110,000 00	62 30	133,998 72	100,096 89	....	33,901 83
Hall of Engineering	....	5,065 81	c145,000.00	150 37	150,216 18	137,689 47	....	12,526 71
Lawson Memorial Prize	....	....	....	25 00	25 00	25 00	....	....
Nursery License	....	....	....	1,455 61	1,455 61	1,455 61	....	....
Sundry Improvements	....	465 65	....	....	465 65	465 65	....	....
Sayer Fund	....	12 20	....	25 00	37 20	25 00	....	12 20
Weather Bureau	....	234 18	1,000 00	....	1,234 18	967 33	....	266 85
Totals	$8,656 87	$34,872 23	$440,059 35	$18,983 76	$485,258 47	$436,830 36	....	$48,428 11

a United States Treasurer.
b $43,059.35 U. S. Treasurer.
c $90,000.00 Gift, R. E. Olds.

TABLE NO. 3.—*William Smith Sayer Scholarship Fund.*

Fund.	Year ending June 30.	Income.	Income expended to.	Amount.	Balance including principal.
$500.00 received of F. F. Sayer, administrator of the estate of William Smith Sayer, to establish Scholarship in Bacteriology	1910	$32.25	A. McVittie....	$19.75	$512 50
	1911	37 50	....	....	550 00
	1912	12 50	D. K. Fisher...	25.00	512 50
			H. K. Wright..	25.00	
	1913	25.00	D. Francisco...	25.00	512.50
	1914	24.85	R. W. Waffle...	25.00	512.35
	1915	24.85	J. D. Baker....	25.00	512 20
	1916	25 00	J. M. Maze....	25 00	512 20
	1917	25.00	Elsa Scheuren..	25.00	512 20
Total....	....	$206 95	....	$194 75	....

TABLE NO. 4.—*Geo. E. Lawson Memorial Prize.*

Fund.	Year ending June 30.	Income.	Income expended to.	Amount.	Balance including principal.
$500.00 received of John W. Beaumont, in memory of Geo. E. Lawson, to offer annual cash prize for best essay in English produced by male student	1917	$25 00	I. B. McMurtry	$25 00	$500 00

TABLE NO. 5.—*Current Account, July 1, 1916, to June 30, 1917.*

On account of—	Dr. To disbursements.	Cr. By receipts.
U. S. Treasurer, 27th annual payment under act of Congress, of Aug., 1890	....	$50,000 00
State Treasurer, one-fifth mill fund	....	394,000 00
State Treasurer, interest on proceeds of sales of U. S. land grant	....	69,437 43
Agricultural Education	$1,067 02	....
Anatomy	1,751 62	900 85
Animal Husbandry	10,841 09	9,922 53
Athletics	3,969 86	1,593 05
Bacteriology	8,562 69	2,769 12
Botany	3,748 33	2,094 54
Chemistry	10,195 23	10,889 39
Civil Engineering	9,081 26	599 50
Dairy Husbandry	62,261 74	59,127 65
Drawing	1,823 09	3 80
Economics	180 42	38 99
Electrical Engineering	3,520 96	244 20
English	544 28	60 00
Entomology	659 96	144 88
Farm Crops	3,079 15	196 02
Farm and Horses	21,162 89	14,820 19
Farm Mechanics	1,685 72	1,171 33
Forestry	4,227 09	1,895 19
History	167 37	70 00
Home Economics	12,871 54	3,948 99
Horticulture	10,949 38	1,442 78
Library	1,798 37	2 45
Mathematics	338 84	166 50
Mechanical Engineering	32,702 63	3,138 75
Meteorology	14 92	12 00
Military Science	1,593 91	101 88
Pathology	3,027 41	3,092 07
Physics	3,287 91	1,088 88
Poultry	5,962 08	2,390 46
Soils	2,316 11	355 11
Special Courses	3,027 43	1,745 00
Veterinary Science	3,454 48	911 04
Zoology	1,430 54	816 65
Advertising	1,936 35	....
Bulletins	3,978 60	252 40
Cleaning	3,724 57	1,022 39
Contingent Building	53,267 73	*a*50,476 22
Dean of Agriculture	2,387 97	3 00
Dean of Summer School	1,198 14	171 00
Electric Lighting	15,277 62	5,444 83
Freight and Cartage	2,147 78	....
Heating	66,696 94	473 53
Hospitals	4,426 33	780 75
Miscellaneous	9,039 74	2,687 67
Office, President's	1,284 94	279 75
Office, Secretary's	4,631 28	2,061 22
Registrar	2,500 64	....
Salaries	285,275 08	2,752 91
Seed Analysis	204 30	221 40
Telephones	1,557 84	314 19
South Haven Experiment Station	3,069 92	170 77
Upper Peninsular Experiment Station	12,362 67	4,608 41
Totals	$706,273 76	$710,911 66
Balance beginning fiscal year, July 1, 1916	....	11,428 52
Balance on hand, June 30, 1917	16,066 42	....
	$722,340 18	$722,340 18

*a*Diploma fees, $1,410.00; incidentals, $10,600.50; matriculation, $2,825.00; room rent, $16,012.03; tuition, $3,612.50; delinquent, $464.00; sundry, $15,552.19.

DISTRIBUTION OF SPECIAL APPROPRIATIONS.

On account of—	Dr. To disbursements.	Cr. By receipts.
Weather Service	$967 33	$1,000 00
Nursery License and Inspection	1,455 61	1,455 61
Sundry Improvements	465 65	....
Sayer Fund	25 00	25 00
Engineering Shops	49,051 00	55,000 00
Gymnasium	100,096 89	110,062 30
Hall of Engineering	137,689 47	145,150 37
Geo. E. Lawson Memorial Fund	25 00	25 00
Totals	$289,775 95	$312,718 28
Balance beginning Fiscal Year, July 1, 1916	....	23,765 26
Balance on hand, June 30, 1917	46,707 59	....
Totals	$336,483 54	$336,483 54

TABLE NO. 6.—*Experiment Station account for fiscal year ending June 30, 1917.*

	Disbursements.			Dr. Total disbursements each department.	Cr. By receipts.
	Adams.	Hatch.	State.		
Balance July 1, 1916	....	....	....	....	$5,157 97
U. S. Treasurer	....	....	....	....	30,000 00
State Treas. 1-5 mill fund	....	....	....	....	15,000 00
Fertilizer fees	....	....	$976 96	$976 96	7,007 26
Commercial Feed Stuffs	....	....	583 43	583 43	9,800 00
Bacteriological	$2,147 27	$513 49	1,361 37	4,022 13	162 44
Botanical	1,024 84	229 91	1,950 86	3,205 61	109 32
Bulletin Clerk	....	....	5 70	5 70	....
Chemical	531 42	710 35	2,191 90	3,433 67	29 29
Dairy Husbandry	....	....	861 19	861 19	....
Director's Office	....	613 33	1,424 89	2,038 22	11 11
Entomological	36 51	134 81	54 13	225 45	....
Farm Crops	....	714 91	1,732 84	2,447 75	3 74
Horticultural	....	562 86	1,145 51	1,708 37	....
Library	....	475 12	5 00	480 12	....
Salaries	9,735 80	9,234 80	23,245 33	42,215 93	....
Secretary's Office	....	....	132 65	132 65	....
Soils	1,524 16	1,810 42	302 45	3,637 03	4 27
Balance June 30, 1917	....	....	....	1,311 19	....
Totals	$15,000 00	$15,000 00	$35,974 21	$67,285 40	$67,285 40

TABLE NO. 7.—*Extension Account for fiscal year ending June 30, 1917.*

On account of projects.	Disbursements.			Dr. Total disburse-ments for each project.	Cr. By receipts.
	Lever.	Lever State.	State.		
U. S. Treasurer, Lever Fund	....	....	....	....	$43,059 35
State Treas. one-fifth mill, Lever State	....	....	....	....	23,500 00
State Treasurer, from one-fifth mill, State	....	....	....	....	17,500 00
Miscellaneous	....	....	....	....	138 05
Administration	$2,700 00	$817 22	$8 44	$3,525 66	....
Boys' and Girls' Club Work	2,774 00	4,352 51	149 64	7,276 15	....
County Agents	20,600 00	3,523 16	115 67	24,238 83	....
Control of Insect Pests	650 00	383 03	....	1,033 03	....
Extension Schools	....	2,396 06	....	2,396 06	....
Farm Crops	2,108 82	1,395 30	34 49	3,538 61	....
Farm Management Demonstrations	436 80	1,272 25		1,709 05	....
Forestry	880 66	378 97	....	1,259 63	....
Horticulture	2,863 77	1,590 69	8 37	4,462 83	....
Home Economics	3,828 50	2,270 47	54 67	6,153 64	....
Household Engineering	1,200 00	413 11	....	1,613 11	....
Institutes	....	....	9,282 57	9,282 57	....
Live Stock	3,216 80	1,693 97	79 63	4,990 40	....
Markets	....	....	4,682 59	4,682 59	....
Potatoes and Vegetables	1,800 00	924 69	8 39	2,733 08	....
Publications	....	1,529 21	....	1,529 21	....
Publicity	....	627 38	....	627 38	....
Upper Peninsula	....	....	28 37	28 37	....
Balance overdrawn, June 30, 1916	....	....	....	2,707 87	....
Balance on hand, June 30, 1917	....	....	....	409 33	....
Totals	$43,059 35	$23,568 02	$14,452 83	$84,197 40	$84,197 40

Vouchers on file from counties for $10,118.71, as offset to Smith-Lever Fund.

TABLE NO. 8.—*Positions and salaries as shown by pay-roll dated June 30, 1917.*

Grade.	Rate per year.	Classification. Current.	Classification. Experiment station.	Extension.
Administration and Miscellaneous:				
President's Office:				
President	$6,500 00	$6,500 00	....	....
Clerk	1,400 00	1,400 00	....	....
Stenographer	850 00	850 00	....	....
Secretary's Office:				
Secretary	2,200 00	b1,500 00	$700 00	....
Cashier	2,000 00	1,800 00	200 00	....
Bookkeeper	1,000 00	900 00	100 00	....
Chief Clerk	1,100 00	975 00	125 00	....
Clerk	850 00	850 00	....	....
Clerk	550 00	550 00	....	....
Clerk	600 00	600 00	....	....
Purchasing Agent	2,100 00	2,100 00	....	....
Registrar's Office:				
Registrar	1,500 00	1,500 00	....	....
Clerk	800 00	800 00	....	....
Assistant to Registrar	1,550 00	1,550 00	....	....
Library:				
Librarian	1,400 00	1,280 00	120 00	....
Assistant Librarian	950 00	950 00	....	....
Assistant	750 00	750 00	....	....
Institute and Nursery Inspection:				
Superintendent	2,300 00	a700 00	....	$1,600 00
Miscellaneous:			....	....
Engineer	1,350 00	1,350 00	....	....
Night Watchman	650 00	650 00	....	....
Nurse	500 00	500 00	....	....
Architect	2,500 00	2,500 00	....	....
Stenographer	800 00	800 00	....	....
Stenographer	600 00	600 00	....	....
Stenographer	600 00	600 00	....	....
Stenographer	600 00	600 00	....	....
Stenographer	600 00	600 00	....	....
Stenographer	600 00	600 00	....	....
Stenographer	600 00	600 00	....	....
Stenographer	600 00	600 00	....	....
Stenographer	650 00	650 00	....	....
Stenographer	650 00	600 00	....	....
Secretary, Y. M. C. A.	500 00	500 00	....	....
Director of Band, Chorus and Glee Club	1,800 00	1,800 00	....	....
Instructor Meteorology	350 00	350 00	....	....
Division of Home Economics:				
Dean's Office:—Dean	3,000 00	3,000 00	....	....
Graduate Assistant	400 00	400 00	....	....
Department of Domestic Art:				
Associate Professor	1,200 00	c1,200 00	....	....
Instructor	900 00	c900 00	....	....
Instructor	750 00	c750 00	....	....
Instructor	850 00	c850 00	....	....
Department of Domestic Science:				
Professor	1,600 00	c1,600 00	....	....
Instructor	900 00	c900 00	....	....
Instructor	800 00	c800 00	....	....
Instructor	800 00	c800 00	....	....
Instructor	850 00	c850 00	....	....
Miscellaneous:				
Instructor Music	1,200 00	1,200 00	....	....
Assistant Instructor Music	800 00	c800 00	....	....
Matron	250 00	c250 00	....	....
House Mother	900 00	c900 00	....	....
Asst. to Dean and Inst. Physical Culture	950 00	c950 00	....	....
Matron	600 00	c600 00	....	....
House Director	850 00	c850 00	....	....

TABLE NO. 8.—*Continued.*

Grade.	Rate per year.	Classification. Current.	Classification. Experiment station.	Extension.
Division of Engineering:				
Dean's Office:				
Dean	$3,500 00	$a3,500 00	....	....
Clerk	660 00	660 00	....	....
Department of Drawing and Design:				
Professor	2,600 00	2,600 00	....	....
Assistant Professor	1,600 00	1,600 00	....	....
Instructor	1,000 00	1,000 00	....	....
Instructor	1,150 00	1,150 00	....	....
Instructor	1,000 00	1,000 00	....	....
Instructor	850 00	850 00	....	....
Instructor	1,200 00	1,200 00	....	....
Department of Civil Engineering:				
Professor	2,500 00	a2,500 00	....	....
Associate Professor	2,100 00	2,100 00	....	....
Assistant Professor	1,700 00	1,700 00	....	....
Assistant Professor	1,550 00	1,550 00	....	....
Assistant Professor	1,500 00	1,500 00	....	....
Instructor	1,400 00	1,400 00	....	....
Instructor	1,300 00	1,300 00	....	....
Instructor	900 00	900 00	....	....
Department of Mechanical Engineering:				
Professor	2,800 00	2,800 00	....	....
Assistant Professor	1,800 00	1,800 00	....	....
Assistant Professor	1,600 00	1,600 00	....	....
Instructor	1,400 00	1,400 00	....	....
Instructor	1,000 00	1,000 00	....	....
Instructor	900 00	900 00	....	....
Instructor	800 00	800 00	....	....
Assistant in Woodshop	1,020 00	1,020 00	....	....
Foreman, Machine Shop	1,200 00	1,200 00	....	....
Assistant in Wood Shop	1,000 00	1,000 00	....	....
Foreman Pattern Shop	1,200 00	1,200 00	....	....
Foreman Foundry	1,000 00	1,000 00	....	....
Foreman Forge Shop	1,400 00	1,400 00	....	....
Shop Engineer	780 00	780 00	....	....
Department of Electrical Engineering:				
Professor	2,800 00	2,800 00	....	....
Assistant Professor	1,550 00	1,550 00	....	....
Division of Science and Letters:				
Department of Bacteriology:				
Professor	2,800 00	2,100 00	$700 00	....
Assistant Professor	1,500 00	1,250 00	250 00	....
Assistant Professor	1,800 00	900 00	900 00	....
Instructor	1,200 00	1,200 00	....	....
Instructor	1,000 00	1,000 00	....	....
Graduate Assistant	200 00	200 00	....	....
Graduate Assistant	200 00	200 00	....	....
Graduate Assistant	200 00	200 00	....	....
Research Assistant	1,800 00	....	1,800 00	....
Research Assistant	1,550 00	....	1,550 00	....
Research Assistant	1,200 00	....	1,200 00	....
Department of Botany:				
Professor	2,500 00	a2,300 00	200 00	....
Associate Professor	1,800 00	1,800 00	....	....
Assistant Professor	1,500 00	1,500 00	....	....
Instructor	1,200 00	1,200 00	....	....
Research Asst. Plant Pathology	1,850 00	800 00	1,050 00	....
Research Asst. Plant Physiology	1,850 00	800 00	1,050 00	....
Instructor	1,100 00	1,100 00	....	....
Instructor	1,300 00	1,300 00	....	....
Instructor	1,200 00	1,200 00	....	....
Graduate Assistant	400 00	400 00	....	....
Graduate Assistant	400 00	400 00	....	....
Assistant In Plant Pathology	1,350 00	....	1,350 00	....
Department of Chemistry:				
Professor	2,300 00	2,300 00	....	....
Associate Professor	2,000 00	2,000 00	....	....
Assistant Professor	1,400 00	1,400 00	....	....

TABLE No. 8.—*Continued.*

Grade.	Rate per year.	Classification. Current.	Experiment station.	Extension.
Department of Chemistry:—Con't				
Instructor	$1,400 00	$1,400 00	....	....
Instructor	1,250 00	1,250 00	....	....
Instructor	1,200 00	1,200 00	....	....
Instructor	1,050 00	1,050 00	....	....
Instructor	1,050 00	1,050 00	....	....
Instructor	1,000 00	1,000 00	....	....
Instructor	1,100 00	1,100 00	....	....
Instructor	1,050 00	1,050 00	....	....
Instructor	950 00	950 00	....	....
Department of English:				
Professor	2,500 00	a2,500 00	....	....
Assistant Professor	1,700 00	1,700 00	....	....
Assistant Professor	1,500 00	1,500 00	....	....
Assistant Professor	1,500 00	1,500 00	....	....
Instructor	1,200 00	1,200 00	....	....
Instructor	1,050 00	1,050 00	....	....
Instructor	1,050 00	1,050 00	....	....
Instructor	1,250 00	1,250 00	....	....
Instructor	1,200 00	1,200 00	....	....
Instructor	1,000 00	1,000 00	....	....
Instructor	1,050 00	1,050 00	....	....
Instructor	1,200 00	1,200 00	....	....
Instructor	1,200 00	1,200 00	....	....
Department of Economics:				
Professor	2,800 00	2,800 00	....	....
Assistant Professor	1,400 00	1,400 00	....	....
Instructor	1,200 00	1,200 00	....	....
Department of Entomology:				
Professor	2,500 00	2,100 00	$400 00	....
Assistant Professor	2,200 00	400 00	1,800 00	....
Instructor	1,200 00	950 00	250 00	....
Instructor	1,000 00	500 00	500 00	....
Specialist, Control Insect Pests	1,350 00	700 00	....	$650 00
Inspector of Apiaries	400 00	400 00	....	....
Department of History:				
Professor	2,800 00	2,800 00	....	....
Instructor	1,100 00	1,100 00	....	....
Department of Mathematics:				
Professor	2,800 00	2,800 00	....	....
Assistant Professor	500 00	500 00	....	....
Assistant Professor	1,550 00	1,550 00	....	....
Instructor	1,350 00	1,350 00	....	....
Instructor	1,450 00	1,450 00	....	....
Instructor	1,500 00	1,500 00	....	....
Instructor	1,325 00	1,325 00	....	....
Instructor	1,250 00	1,250 00	....	....
Instructor	1,325 00	1,325 00	....	....
Instructor	1,400 00	1,400 00	....	....
Department of Military Science:				
Sergeant and Instructor in Military Science	1,250 00	1,250 00	....	....
Department of Physics:				
Associate Professor	2,000 00	2,000 00	....	....
Assistant Professor	1,450 00	1,450 00	....	....
Instructor	1,350 00	1,350 00	....	....
Instructor	1,300 00	1,300 00	....	....
Department of Zoology:				
Professor	2,500 00	a2,500 00	....	....
Assistant Professor	1,500 00	1,500 00	....	....
Assistant Professor	1,500 00	1,500 00	....	....
Assistant Professor	1,400 00	1,400 00	....	....
Instructor	1,250 00	1,250 00	....	....
Instructor	1,150 00	1,150 00	....	....
Instructor	1,050 00	1,050 00	....	....
Instructor	960 00	960 00	....	....

TABLE NO. 8.—*Continued.*

Grade.	Rate per year.	Classification.		Extension.
		Current.	Experiment station.	
Division of Veterinary Science:				
Veterinary Department:				
Dean	$3,300 00	$3,300 00	....	....
Assistant Professor of Pharmacology	1,800 00	1,800 00	....	....
Department of Anatomy:				
Associate Professor	2,100 00	2,100 00	....	....
Department of Pathology:				
Associate Professor	2,100 00	2,100 00	....	....
Instructor	1,700 00	1,700 00	....	....
Division of Agriculture:				
Dean's office:				
Dean	3,800 00	a2,300 00	$1,500 00	....
Clerk	700 00	700 00	....	....
Department of Agricultural Education:				
Professor	2,800 00	2,800 00	....	....
Assistant Professor	1,750 00	1,750 00	....	....
Department of Animal Husbandry:				
Associate Professor	2,000 00	1,800 00	200 00	....
Instructor	1,650 00	1,650 00	....	....
Instructor	840 00	840 00	....	....
Department of Dairy Husbandry:				
Professor	2,800 00	2,600 00	200 00	....
Assistant Professor	1,650 00	1,650 00	....	....
Instructor	1,000 00	1,000 00	....	....
Instructor	770 00	770 00	....	....
Instructor	900 00	900 00	....	....
Instructor	1,200 00	1,200 00	....	....
Clerk	660 00	660 00	....	....
Clerk	700 00	700 00	....	....
Assistant in Dairying	1,200 00	....	1,200 00	....
Assistant in Dairying	950 00	....	950 00	....
Assistant in Dairying	900 00	....	900 00	....
Department of Farm Crops:				
Professor	1,900 00	1,900 00	....	....
Expert in Plant Breeding	1,950 00	450 00	1,500 00	....
Instructor	400 00	400 00	....	....
Assistant in Farm Crops	900 00	....	900 00	....
Department of Farm and Horses:				
Superintendent	1,400 00	1,400 00	....	....
Department of Farm Mechanics:				
Associate Professor	2,000 00	1,650 00	350 00	....
Instructor	1,000 00	1,000 00	....	....
Instructor	1,000 00	1,000 00	....	....
Instructor	780 00	780 00	....	....
Department of Poultry Husbandry:				
Associate Professor	1,400 00	1,200 00	200 00	....
Department of Forestry:				
Professor	2,800 00	2,600 00	200 00	....
Assistant Professor	2,000 00	2,000 00	....	....
Instructor	1,800 00	1,800 00	....	....
Instructor	800 00	800 00	....	....
Department of Horticulture:				
Professor	3,000 00	a2,100 00	900 00	....
Associate Professor	2,600 00	2,300 00	300 00	....
Instructor	1,600 00	1,600 00	....	....
Instructor	1,400 00	1,400 00	....	....
Foreman of Orchards	900 00	900 00	....	....
Research Assistant in Horticulture	1,200 00	....	1,200 00	....
Research Assistant in Horticulture	1,200 00	....	1,200 00	....
Assistant in Horticulture	1,550 00	....	1,550 00	....
Department of Soils:				
Professor	2,800 00	2,200 00	600 00	....
Assistant Professor	1,750 00	1,750 00	....	....

TABLE No. 8.—*Continued.*

Grade.	Rate per year.	Classification. Current.	Classification. Experiment station.	Extension.
Department of Soils:—Con't				
Instructor	$1,750 00	$1,750 00		
Instructor	1,400 00	1,400 00		
Instructor	1,000 00	1,000 00		
Graduate Assistant	400 00	400 00		
Research Assistant in Soils	2,200 00		$2,200 00	
Research Assistant in Soils	1,100 00		1,100 00	
Chemistry Division, Exp. Station:				
Chemist	2,800 00		2,800 00	
Research Assistant in Chemistry	1,000 00		1,000 00	
Assistant in Chemistry	1,650 00		1,650 00	
Assistant in Chemistry	1,150 00		1,150 00	
Assistant in Chemistry	1,100 00		1,100 00	
Assistant in Chemistry	1,200 00		1,200 00	
Stenographer	600 00		600 00	
Bulletin Clerk	660 00		660 00	
Inspector	1,200 00		1,200 00	
Division of Extension:				
Administration:				
Director	2,000 00			$2,000 00
Clerk	700 00			700 00
County Agents:				
State Leader	1,100 00			1,100 00
Assistant State Leader	700 00			700 00
Agent, Allegan County	600 00			600 00
Agent, Alpena County	600 00			600 00
Agent, Berrien County	900 00			900 00
Agent, Branch County	600 00			600 00
Agent, Cheboygan County	600 00			600 00
Agent, Dickinson County	600 00			600 00
Agent, Gogebic County	600 00			600 00
Agent, Houghton County	600 00			600 00
Agent, Iron County	600 00			600 00
Agent. Kent County	700 00			700 00
Agent, Lenawee County	600 00			600 00
Agent, Marquette County	600 00			600 00
Agent, Mason County	900 00			900 00
Agent, Muskegon County	900 00			900 00
Agent, Newaygo County	600 00			600 00
Agent, Ontonagon County	600 00			600 00
Agent, Ottawa County	900 00			900 00
Agent, Saginaw County	600 00			600 00
Agent, Schoolcraft County	900 00			900 00
Agent, St. Clair	600 00			600 00
Agent, St. Joseph County	600 00			600 00
Agent, Van Buren County	900 00			900 00
Agent, Wexford County	600 00			600 00
Agent, Manistee County	600 00			600 00
Agent, Menominee County	900 00			900 00
District Agent, Upper Peninsula	1,600 00			1,600 00
Home Economics:				
Specialist	1,600 00			1,600 00
Assistant	1,200 00			1,200 00
Assistant	800 00			800 00
Assistant	1,000 00			1,000 00
Boys and Girls Club Work:				
State Agent	700 00			700 00
Assistant	700 00			700 00
Assistant	850 00			850 00
Farm Crops:				
Specialist	1,200 00			1,200 00
Live Stock:				
Specialist	2,000 00			2,000 00
Assistant	1,200 00			1,200 00
Horticulture:				
Specialist	2,000 00			2,000 00
Potatoes and Vegetables:				
Specialist	1,800 00			1,800 00

TABLE No. 8.—*Concluded.*

Grade.	Rate per year.	Classification.		Extension.
		Current.	Experiment station.	
Household Engineering:				
Specialist	$1,200 00	....	....	$1,200 00
Forestry:				
Specialist	1,200 00	....	....	1,200 00
Institutes:				
Stenographer	600 00	....	....	600 00
Markets:				
Director	1,800 00	....	....	1,800 00
Assistant	300 00	....	....	300 00
Publications:				
Clerk	480 00	....	....	480 00
Totals	$361,310 00	$272,375 00	$42,755 00	$46,180 00

(a) House.
(b) Other sources, $1,000.00. House.
(c) Use of rooms.

TABLE NO. 9.—*Salaries experiment station, fiscal year ending June 30, 1917.*

Director	$1,500 00
Bacteriologist	700 00
Assistant Bacteriologist	250 00
Research Assistant in Bacteriology	1,800 00
Research Assistant in Bacteriology	1,541 60
Research Assistant in Bacteriology	891 60
Research Assistant in Bacteriology	118 00
Research Assistant in Bacteriology	997 80
Botanist	200 00
Research Assistant in Plant Pathology	1,050 00
Research Assistant in Plant Physiology	1,041 50
Research Assistant in Plant Pathology	1,341 50
Assistant in Celery Work	98 91
Chemist	2,799 80
Research Assistant in Chemistry	1,168 60
Assistant in Chemistry	1,594 20
Assistant in Chemistry	1,141 70
Assistant in Chemistry	1,130 40
Assistant in Chemistry	997 80
Assistant in Chemistry	743 24
Assistant in Chemistry	749 20
Inspector	997 80
Associate Animal Husbandman	200 00
Dairy Husbandman	200 00
Assistant in Dairying	941 60
Assistant in Dairying	1,174 70
Assistant in Dairying	748 40
Entomologist	400 00
Research Assistant in Entomology	1,800 00
Assistant in Entomology	250 00
Assistant in Entomology	125 00
Assistant in Entomology	125 00
Farm Crops Experimenter	225 00
Assistant in Farm Crops	900 00
Expert in Plant Breeding	1,500 00
Associate in Farm Mechanics	350 00
Forester	200 00
Horticulturist and Vice-Director	900 00
Associate Horticulturist	300 00
Research Assistant in Horticulture	600 00
Research Assistant in Horticulture	1,200 00
Assistant in Horticulture	1,541 70
Assistant in Potato Work	96 13
Associate Poultry Husbandman	200 00
Soil Physicist	600 00
Research Assistant in Soils	2,199 90
Research Assistant in Soils	90 70
Librarian	120 00
Secretary	700 40
Cashier	200 00
Bookkeeper	75 00
Bookkeeper	25 00
Clerk	125 00
Stenographer	44 25
Stenographer	544 50
Bulletin Clerk	660 00
Total	$42,215 93

TABLE NO. 10.—*Salaries Extension—Lever fund for fiscal year ending June 30, 1917.*

Administration:	
Director	$2,000 00
Clerk	700 00
County Agents:	
State Leader	1,100 00
Assistant State Leader	700 00
Agent, Allegan County	600 00
Agent, Alpena County	600 00
Agent, Berrien County	900 00
Agent, Branch County	600 00
Agent, Cheboygan County	600 00
Agent, Dickinson County	600 00
Agent, Gogebic County	600 00
Agent, Houghton County	600 00
Agent, Iron County	600 00
Agent, Kent County	700 00
Agent, Lenawee County	600 00
Agent, Marquette County	600 00
Agent, Mason County	900 00
Agent, Muskegon County	900 00
Agent, Newaygo County	600 00
Agent, Ontonagon County	600 00
Agent, Ottawa County	900 00
Agent, Saginaw County	600 00
Agent, Schoolcraft County	900 00
Agent, St. Clair County	600 00
Agent, St. Joseph County	600 00
Agent, Van Buren County	900 00
Agent, Wexford County	600 00
Agent, Manistee County	600 00
Agent, Menominee County	900 00
District Agent in charge of Upper Peninsula	1,600 00
Home Economics:	
Specialist	1,583 20
Assistant	1,166 20
Assistant	665 20
Assistant	413 90
Boys and Girls Club Work:	
State Agent	683 00
Assistant	699 90
Assistant	841 60
Stenographer	499 50
Farm Crops:	
Specialist	1,200 00
Specialist	908 82
Live Stock:	
Specialist	2,000 00
Assistant	1,216 80
Horticulture:	
Specialist	2,000 00
Specialist	1,028 57
Potatoes and Vegetables:	
Specialist	1,800 00
Farm Management Demonstrations:	
Demonstrator	436 80
Entomology:	
Specialist, Control of Insect Pests	650 00
Household Engineering:	
Specialist	1,200 00
Forestry:	
Specialist	900 00
Institutes:	
Superintendent	1,600 00
Stenographer	600 00
Markets:	
Director	1,800 00
Assistant Director	798 90
Publications:	
Clerk	439 60
Total	$48,431 99

TABLE NO. 11.—*Income of the Michigan Agricultural College from all outside sources from the date of its foundation to the present time.*

Year.	From State Legislature.			From U. S. Congress.				Total.
	For current expenses.	For special purposes	Land sales, salt spring and swamp land grants.	Morrill act of 1862, interest from land grant and trespass.	Hatch act of 1887, and Adams act of 1906, experiment station.	Morrill act of 1890, supplementary endowment.	Smith Lever act of 1914, extension.	
1855			$56,320 00					$56,320 00
1856								
1857	$40,000 00							40,000 00
1858								
1859	37,500 00							37,500 00
1860								
1861	6,500 00		152 25					6,652 25
1862	10,000 00		218 97					10,218 97
1863	9,000 00		407 80					9,407 80
1864	9,000 00		726 09					9,726 09
1865	15,000 00		1,156 61					16,156 61
1866	15,000 00		1,094 27					16,094 27
1867	20,000 00		7,608 38					27,608 38
1868	20,000 00		592 49					20,592 49
1869	20,000 00	$30,000 00	17,559 00	$58 96				67,617 96
1870	20,000 00		1,320 02	2,720 93				24,040 95
1871	18,250 00	10,500 00	4,135 72	3,785 54				36,671 26
1872	18,250 00	3,000 00	217 05	7,175 65				28,642 70
1873	21,796 00	15,602 00	10 13	11,059 06				48,467 19
1874	13,000 00	15,602 00	150 13	14,061 98				42,814 11
1875	7,638 00	7,755 50	144 53	14,446 14				29,984 17
1876	7,638 00	6,755 50	1,773 09	16,830 17				32,996 76
1877	6,150 00	30,686 80	979 06	15,172 86				52,988 72
1878	6,150 00	5,686 80	826 60	15,807 09				28,470 49
1879	4,971 80	16,068 32	712 22	16,978 22				38,730 56
1880	4,971 80	7,068 32	797 55	17,837 24				30,674 91
1881	7,249 00	43,720 50	461 95	20,935 25				72,366 70
1882	7,249 00	8,945 50	358 46	22,507 45				39,060 41
1883	8,385 00	23,793 00	391 95	30,749 60				63,319 52
1884	8,385 00	10,526 00	1,259 90	27,909 72				48,080 65

1885		35,103 00	187 50	29,770 40				65,060 90
1886		22,617 00		30,461 04				53,078 04
1887		*44,040 00	198 20	†24,611 37				68,849 57
1888		30,752 50	144 20	32,406 60	$15,000 00			78,303 30
89		*20,973 00	10 50	31,322 69	15,000 00			67,306 19
1890		*27,172 00	238 50	32,360 64	15,000 00	$15,000 00		89,771 14
1891		22,947 50	37 38	34,750 54	15,000 00	16,000 00		88,735 42
1892		22,947 50	137 38	34,948 12	15,000 00	17,000 00		90,033 00
1893		18,862 50	10 50	37,927 04	15,000 00	18,000 00		89,800 04
1894		18,862 50	433 59	44,527 26	15,000 00	19,000 00		97,823 35
1895		‡19,000 00	10 50	45,301 85	15,000 00	20,000 00		99,312 35
1896		‡16,000 00		43,886 40	15,000 00	21,000 00		95,886 40
1897		§17,700 00		43,779 54	15,000 00	22,000 00		98,479 54
1898		‖17,500 00		47,508 28	15,000 00	23,000 00		103,008 28
1899		¶8,750 00	705 00	52,526 11	15,000 00	24,000 00		100,981 11
1900		¶72,500 00	175 00	72,298 38	15,000 00	25,000 00		184,973 38
1901††		¶72,500 00		63,976 79	15,000 00	25,000 00		176,476 79
1902	100,000 00	**1,000 00		64,081 81	15,000 00	25,000 00		205,081 81
1903	100,000 00	**1,000 00		65,573 90	15,000 00	25,000 00		206,573 90
1904	100,000 00	**1,000 00	61 19	67,312 37	15,000 00	25,000 00		208,373 56
1905	100,000 00	*81,000 00		72,035 32	15,000 00	25,000 00		293,035 32
1906	157,810 00	*15,000 00		70,286 56	15,000 00	25,000 00		283,096 56
1907	173,410 00	**1,000 00		70,155 22	23,691 60	25,000 00		293,256 82
1908	173,410 00	**1,000 00		70,385 79	23,326 10	30,000 00		298,121 89
1909	173,410 00	**1,000 00		69,527 13	26,000 00	35,000 00		304,937 13
1910	173,410 00	**1,000 00		71,109 49	28,000 00	40,000 00		313,519 49
1911	173,410 00	**1,000 00		70,304 15	30,000 00	45,000 00		319,714 15
1912	228,800 00	**1,000 00		70,265 32	30,000 00	50,000 00		380,065 32
1913	228,800 00	**1,000 00		70,289 30	30,000 00	50,000 00		380,089 30
1914	228,800 00	**1,000 00		71,324 94	30,000 00	50,000 00		381,124 94
1915	308,147 25	**1,000 00		70,385 46	30,000 00	50,000 00	$10,000 00	469,532 71
1916	560,000 00	**1,000 00		71,391 56	30,000 00	50,000 00	28,032 37	740,423 93
1917	560,000 00	**1,000 00		69,437 43	30,000 00	50,000 00	43,059 35	753,496 78
Totals	$3,901,490 85	$833,937 74	$101,723 66	$2,054,264 66	$596,017 70	$845,000 00	$81,091 72	$8,413,526 33

*Including appropriation for weather service.
†October 1, 1886, to June 30, 1887, nine months.
‡Including $5,000 for institutes and $1,000 for weather service.
‖Including $5,500 for institutes and $1,000 for weather service.
§Including $2,750 for institutes and $500 for weather service.
††To June 30.
**Weather service.
¶Including $5,500 for institutes and $1,000 for weather service.

SUMMARY OF COLLEGE INVENTORY, JUNE 30, 1916.

College farm and park, 671 acres		$67,100 00
Athletic field and drive, 13 acres		1,300 00
Purchased C. D. Woodbury, 1916, 308.82 acres		38,602 50
Purchased in 1913, 27 acres		3,375 00
Buildings—		
Library and museum, built 1881	$22,000 00	
College Hall, built 1856	12,000 00	
Wells Hall, rebuilt 1905-06	55,000 00	
Williams Hall, built in 1869	30,000 00	
Abbot Hall, built 1888, addition in 1896	15,000 00	
Chemical Laboratory, built in 1871, south end addition 1881, east end addition 1911	35,000 00	
Veterinary laboratory, built 1885	5,000 00	
Horticultural laboratory, built 1888	7,000 00	
Entomological laboratory, built 1889, imp. 1897	7,500 00	
Botanical laboratory, built 1892, imp. 1909	20,000 00	
Armory, built 1885	6,000 00	
Greenhouse and stable, built 1873, 1879, rebuilt 1892 and 1902	6,000 00	
Boiler house and chimney, built 1893-4	3,000 00	
President's and two frame dwellings, built 1874	12,000 00	
Six brick dwellings, built 1857, 1879 and 1884	18,000 00	
One frame house, built 1885	3,500 00	
Howard Terrace dwelling, built 1888	13,000 00	
Farm house dwelling, built 1869	2,000 00	
Herdsman's dwelling, built 1867	400 00	
Horticultural barn and shed, built 1868, 1875 and 1877	1,200 00	
Bull barn, rebuilt 1905	1,500 00	
Sheep barn, rebuilt 1906	2,500 00	
Horse barn, built 1906	5,000 00	
Grade herd barn, rebuilt 1905	4,000 00	
Piggery, rebuilt 1907	1,500 00	
Dairy barn, rebuilt 1900	4,000 00	
Farm mechanics building, built 1881	1,500 00	
Poultry house, built 1906	1,000 00	
Incubator house, built 1906	500 00	
Poultry house, built 1907	1,500 00	
Three poultry houses, built 1907	300 00	
Ten brooder houses, built 1908	250 00	
Corn barn, built 1878	400 00	
Stock judging barn, built 1894	200 00	
Brick work shop, built 1857	500 00	
Observatory, built 1880	100 00	
Bath house and fittings, built 1902-3	17,000 00	
Hospital, built 1894	3,000 00	
Waiting room and book store, built 1902	1,700 00	
Three silos	600 00	
Coal shed, built 1899	700 00	
Women's building, built 1909	91,000 00	
Dairy building, built 1900	15,000 00	
Bacteriological building, built 1902	27,000 00	
Power house, built 1904	25,000 00	
Tunnel system, built 1904	45,000 00	
Coal shed, built 1905	6,500 00	
Cold storage, rebuilt 1905	2,000 00	
Amount carried forward	$532,850 00	$110,377 50

Amount brought forward	$532,850 00	$110,377 50
Buildings—Continued.		
Iron bridge over Cedar river, built 1888	1,500 00	
Bridge to athletic field	500 00	
Manure shed	600 00	
Four hospital cottages, built 1909	6,000 00	
Agricultural building, built 1909	182,000 00	
Lumber shed, built 1911	650 00	
Tile silo No. 1	500 00	
Piggery for serum production	1,000 00	
Two tenant dwellings, built 1912	2,400 00	
New dairy building, built 1913	55,000 00	
Tile silo No. 2	600 00	
Tile silo No. 3	600 00	
Veterinary laboratory, 1914	33,000 00	
Special chemical laboratory	800 00	
		818,000 00
Division of Agriculture—		
Department of Agricultural Education		767 31
Department of Animal Husbandry—		
Office furniture and supplies	$501 48	
Office library	843 45	
Stock	14,661 00	
Feed	1,297 15	
Miscellaneous tools and equipment	715 15	
		18,018 23
Department of Dairy Husbandry—		
Office	$2,034 98	
Chemicals and laboratory supplies	6,564 59	
Dairy barn	14,821 35	
		23,420 92
Office of the Dean of Agriculture—		
Furniture and supplies	$706 11	
Class room furniture	1,454 40	
		2,160 51
Department of Farm Crops		2,382 85
Department of Farm and Horses—		
Tool barn	$4,232 71	
Woodbury farm	654 51	
Horses	12,820 00	
Horse barn	833 20	
Office	328 79	
		18,869 21
Department of Farm Mechanics—		
Office	$867 02	
Forge shop	1,788 12	
Wood shop	1,381 65	
Machinery laboratory	1,372 98	
		5,409 77
Department of Forestry—		
Office furniture and supplies	$704 75	
Laboratory and class room equipment	3,885 65	
Book and pamphlets	700 00	
Instruments	752 05	
Tools and supplies	600 25	
Camp equipment	528 00	
Photography equipment	202 82	
Nursery stock	6,154 00	
		13,527 52
Amount carried forward		$1,012,933 82

Amount brought forward		$1,012,933 82
Department of Horticulture—		
Office	$2,007 33	
Teams and harness	1,238 50	
Class room	457 00	
Laboratory equipment	662 93	
Tools	272 35	
Greenhouse plants	898 00	
Greenhouse tools	337 60	
		5,873 71
Department of Poultry Husbandry—		
Office furniture	$227 35	
Supplies	36 47	
Books	102 63	
Tools and supplies	439 61	
Miscellaneous	4,301 82	
Live stock	2,035 30	
Feed	142 71	
		7,285 89
Department of Soils—		
Apparatus and supplies	$6,839 17	
Furniture	570 79	
Chemicals	241 24	
Extension	11 40	
		7,662 60
Division of Engineering—		
Department of Civil Engineering—		
Astronomical equipment	$772 60	
Blue printing, drawing and photography	423 21	
Drafting and computing equipment	111 94	
Furniture and office supplies	110 92	
Hydraulic laboratory	215 65	
Library	9 80	
Surveying equipment	5,333 98	
Tools	50 40	
		7,028 50
Department of Drawing and Design—		
Equipment	$231 51	
Books	10 83	
Supplies	21 20	
Tools	15 40	
		278 94
Department of Mechanical Engineering—		
Office	$642 38	
Mechanical engineering laboratory	7,532 57	
Foundry	2,613 41	
Forge shop	2,219 07	
Pattern shop	895 49	
Machine shop	10,072 14	
		23,975 06
Department of Physics and Electrical Engineering—		
Books	$5 95	
Furniture and office equipment	538 30	
Supplies	118 00	
Apparatus	10,783 01	
		11,445 26
Amount carried forward		$1,076,483 78

Amount brought forward		$1,076,483 78
Division of Extension—		
Administration	$811 88	
Upper Peninsula	171 23	
Boys' and Girls' Clubs	368 15	
Live stock	186 40	
Insect pests	45 00	
Horticulture	7 25	
Farm crops	40 50	
Home Economics	168 05	
County agents and farm management demonstration	700 01	
Markets	78 87	
Farmers' Institutes	549 90	
		3,127 24
Division of Home Economics—		
Dean's Office	$374 92	
Drawing room	457 00	
Reception room	232 00	
Front corridor	245 75	
Second floor corridor	22 00	
Alcove	111 25	
Central corridor	129 85	
Private parlor	138 15	
Bed room	88 68	
Guest room	89 00	
Domestic science	2,159 09	
Domestic art	1,802 80	
Music	3,452 80	
Physical culture	920 97	
Dormitory furniture	1,304 70	
Howard terrace	1,062 83	
College cottage	546 86	
Day students waiting rooms and corridor	55 00	
Recitation room	41 45	
Linen closet	1,755 33	
Store room	78 02	
Laundry	48 00	
		15,116 45
Division of Science and Letters—		
Department of Bacteriology—		
Literature	$383 92	
Apparatus and supplies	14,980 17	
Office fixtures and supplies	968 14	
Chemicals	2,218 90	
		18,551 13
Department of Botany—		
Books and periodicals	$1,919 13	
Furniture	1,954 75	
Miscellaneous supplies	349 00	
Laboratory supplies	1,252 17	
Chemicals	231 59	
Apparatus	5,796 10	
Glassware	2,111 15	
Tools	65 72	
Herbarium	8,022 35	
		21,701 96
Amount carried forward		$1,134,980 56

Amount brought forward		$1,134,980 53
Department of Chemistry—		
Furniture and fixtures	$7,221 75	
Laboratory supplies	22,694 09	
Chemicals	2,126 50	
Minerals	335 84	
Apparatus	14,856 95	
Platinum	5,552 28	
Tools	75 13	
Miscellaneous	475 63	
		53,338 17
Department of English—		
Furniture	$514 75	
Books and office supplies	675 25	
Miscellaneous	128 73	
		1,318 73
Department of Entomology—		
Office Equipment and Collection	$5,301 25	
Apiary	211 24	
Apparatus and tools	2,040 72	
Books	251 71	
Supplies	265 18	
Glassware	176 60	
Chemicals	58 71	
Sundry	30 99	
		8,336 40
Department of History and Economics—		
Economics	$206 50	
Political science and history	280 25	
		486 75
Department of Mathematics		649 70
Department of Military Science and Tactics—		
Furniture and supplies	$1,986 90	
Band properties	3,108 50	
		5,095 40
Department of Physical Culture and Athletics		262 45
Department of Zoology and Physiology—		
Apparatus and supplies	$10,528 45	
General museum	19,970 00	
Books	632 50	
		31,184 95
Division of Veterinary Medicine—		
General equipment	$915 18	
Department of medicine	240 57	
Surgery and obstetrics	3,875 73	
Department of anatomy	10,419 16	
Department of animal pathology	7,363 95	
Department of pharmacology	1,735 12	
		24,549 71
Miscellaneous—		
Carpenter shop		3,444 48
Cleaning		417 50
Dean of Summer Session		129 50
Amount carried forward		$1,264,194 30

Amount brought forward		$1,264,194 30
Hospitals—		
General hospital	$319 17	
Cottage hospitals	929 88	
		1,249 05
Library		74,245 71
Meteorological department		355 95
Michigan Weather Service		979 00
Department of Nursery and Orchard Inspection		209 25
Paint shop		1,543 84
Postoffice		1,133 45
President's Office		857 63
Registrar's Department—		
Registrar's office	$359 31	
Alumni office	190 22	
		549 53
Secretary's office—		
Furniture and equipment	$1,431 41	
Supplies	865 20	
		2,296 61
Sundry		3,315 32
Wells Hall		2,476 26
Department of Water, Heat and Light—		
Fire department	$2,592 55	
Generating plant	6,029 00	
Tools	1,756 29	
Miscellaneous supplies	442 82	
Plumbing and heating stock	2,042 34	
Telephone stock	2,007 73	
Steam heating plant	14,235 30	
Electric light stock	1,643 94	
H. R. Tools	73 31	
Office furniture and fixtures	107 54	
Bath house plant	142 20	
Waterworks plant	14,463 00	
		45,536 02
Total		$1,398,941 92

SUMMARY OF EXPERIMENT STATION INVENTORY.

Lands—		
160 acres at Chatham	$8,000 00	
140 acres at Chatham, seeded and fenced	4,200 00	
480 acres at Chatham, raw and cut over lands	4,800 00	
80 acres at Grayling, fenced and improved	1,000 00	
5 acres at South Haven, fenced and improved	1,000 00	
		$19,000 00
Buildings—		
Farm residence at Chatham	$5,000 00	
Tenant house at Chatham	1,500 00	
Barn, at Chatham	3,000 00	
Root cellar at Chatham	1,000 00	
Hog house at Chatham	750 00	
Ice house at Chatham	500 00	
Chicken house at Chatham	250 00	
Old barn at Chatham	250 00	
Granary at Chatham	200 00	
Sheep barn at Chatham	1,200 00	
Piggery at Chatham	500 00	
Bacteriological stable	3,700 00	
House	1,000 00	
Station terrace building	3,000 00	
Seed room	500 00	
Slaughter house	625 00	
Storage barn	600 00	
Insectary	1,000 00	
Soil house	1,000 00	
		25,575 00
Division of Experiment Station—		
Division of Bacteriology—		
Literature	$650 80	
Apparatus	11,394 68	
Office fixtures and supplies	235 41	
Chemicals	690 48	
		12,971 37
Division of Botany—		
Chemicals	$592 23	
Glassware	1,048 87	
Scientific apparatus	3,629 35	
Laboratory supplies	401 09	
Books	130 78	
Office, herbarium and garden supplies	1,371 28	
		7,173 60
Bulletin Room		2,538 32
Division of Chemistry—		
Chemicals	$860 51	
Glassware	2,568 48	
Porcelain ware	263 08	
Miscellaneous	6,296 51	
Office furniture and supplies	820 98	
		10,809 56
Director's office		543 03
Amount carried forward		$78,610 88

Amount brought forward		$78,610 88
Division of Entomology—		
Office	$882 49	
Furniture	568 31	
Apparatus	2,029 68	
Books	1,258 19	
Glassware	329 05	
Chemicals	205 50	
Chemical supplies	29 01	
Supplies	47 00	
Stains	17 82	
Tools and machinery	100 56	
Sundry	106 06	
		5,573 67
Division of Farm Crops		2,475 90
Division of Horticulture—		
Office	$409 75	
Tools	1,658 55	
		2,068 30
Library		8,163 85
Division of Soils—		
Apparatus and supplies	$1,944 13	
Chemicals	10 34	
		1,954 47
South Haven Experiment Station		290 84
Upper Peninsula Experiment Station—		
Tools and supplies	$1,941 87	
Live stock	8,271 50	
Crops	928 00	
		11,141 37
Total		$110,279 28

REPORT OF THE PRESIDENT.

To the State Board of Agriculture:

Gentlemen—For the third time in the sixty years since M. A. C. was founded, our College has been obliged to harmonize as best it could the demands of the class room and laboratory with the call to the patriotic citizen for service to the government.

The work of the fall and winter term was carried to successful completion without hinderance but the opening of the spring term occurred simultaneously with the declaration of war by President Wilson; it was natural, therefore, that the student body on assembling did so under a great deal of excitement. A mass meeting called of the entire student body and faculty considered what was the duty of M. A. C. under war conditions and it was soon decided that Military Drill should be increased in amount; that students who desired to enlist for the Officers' Training Camps who belonged to the senior class should be granted their diplomas and that members of the junior class entering the training camp should also be given credit for the spring term's work. Also that those juniors and seniors who were needed at home for farm service should be excused and credited for work under the same conditions as though they had entered military training. The following list gives the names of juniors and seniors who left College to enter military officers training:

Senior Ags.

Clayton F. Barnett	Leonard Verschoor
Abraham H. Bayer	Paul J. Vevia
Fred England	Walter R. Wright
Harold D. Hardy	Arthur Turner
Edw. W. Pinckney	L. Leavitt
Howard G. Smith	G. G. Dicker

Senior Engrs.

Herbert C. Bartlett	George J. Henshaw
Kenneth C. Beake	Frank W. Marx
Harry Lee Campbell	Daniel Leo Mead
W. Harold Cornelius	James B. Rasbach
H. N. Fox	F. Ward Stafford
Ralph B. Henning	Wm. D. Thompson

Junior Ags.

L. V. Benjamin	Stanley W. MacKenzie
Edwin R. Clark	George G. Maxfield
William A. Corson	Wilfred D. Mills
Earl J. Finch	Wayne A. L. Quigley
Clarence H. Hiller	Robert S. Raven
Warren J. Hoyt	Harry K. Wrench
Earl R. VanLeeuwan	George S. Clark (Aviation)
G. L. Lawton	

Junior Engrs.

Roy Merchant Heasley	Carl F. Miller
Maurice G. Jewett	Thomas J. Nicol
Leland N. Jones	Burton F. Orcutt
Charles L. Margeson	Ernest A. Rudelius
Forrest G. Millard	B. Bellinger

Senior Foresters

H. A. Clemetsen	B. M. McClure
Sheldon B. Lee	

Junior Vets.

C. U. Fisher	Harry Weckler
Clifford Heustis	

Excused for Agricultural Work.

Stanley J. Culver	Alfred T. Halsted
Frank B. Harris	Paul Jamieson
Arne G. Kettunen	Jno. C. Kelham
Howard V. Kittle	Dwight Long
Henry N. Putnam	Clare F. Rossman
Howard C. Rather	Glen O. Stewart
Frank T. Warner	Wm. F. Vanbuskirk
Mead Burton	

STATE CONSTABULARY.

The creation by act of legislature of an emergency fund of five million dollars for protective purposes during the war led to the enlistment of a State Constabulary. The Board of Agriculture on application from the State Government May 8th, 1917, granted to the "War Board" the use of 96 acres of the newly acquired Woodbury farm lying west of Harrison avenue on the south side of the river. This camp site is now occupied by two hundred members of that organization including two hundred horses and complete military equipment.

DEPARTMENT CHANGES.

Beginning September 1st, 1916, the Board authorized the establishment of a separate department of Physics, placing Associate Professor C. W. Chapman in charge and creating a department of Electrical Engineering in the Engineering division retaining Professor A. R. Sawyer as head of the department.

A division was also made of the work of the department of History and Economics. Dr. W. O. Hedrick retaining his former position as head of the department of Economics and Professor E. H. Ryder being made head of the department of History and Political Science.

Following the resignation of Professor J. F. Macklin, Director of Athletics, Mr. Frank Sommer of the University of Pennsylvania was secured temporarily for the fall term of 1916 and acted as Foot-ball Coach.

Professor Chester L. Brewer was invited to return to us after a seven years absence at Missouri University being elected Director of Physical Training February 22, 1917. Mr. Brewer and the new gymnasium (when completed) assures the best in physical development for our students.

Lieutenant Max S. Murray was detailed by the War Department September 15th, 1916, as Assistant Professor of Military Science. Both Lieutenant Murray and Captain Ira Longanecker, Commandant, were withdrawn from detail with this College, June 1, 1917. The services of the above named officers together with the energy and enthusiasm of Sergeant Patrick J. Cross (permanently assigned) have inspired our students in their work in Military Science.

RESIGNATIONS.

Associate Professor Wm. L. Lodge, (Physics), September 1, 1916.
Assistant Professor Milton Simpson, (English), September 1, 1916.
Assistant Professor J. S. McDaniel, (Veterinary), January 1, 1917.
Professor V. M. Shoesmith, (Farm Crops), April 1, 1917.

Mr. C. S. Langdon, M. A. C. Association Secretary and Editor of the Record since the fall of 1914, resigned June 1st, to go to the farm. In addition to the very effective service rendered in the above lines of work, he was largely instrumental in enlisting the interest of the Alumni and old students in establishing a prize fund for the encouragement of interest in public speaking. The fund so far contributed amounts to about $500.00.

LEAVES OF ABSENCE.

[Granted for year of study at other institutions.]

Assistant Professor L. C. Emmons, (Mathematics), Harvard.

Research Chemist Chas. S. Robinson, (Experiment Station Chemist), at University of Michigan.

H. C. L.

America's entrance into the war was foreshadowed by the high cost of food materials which seemed to threaten seriously the attendance of our students during the current year, but thanks to the efficiency of our Student Boarding Club Association (organized in 1882) the cost to the individual student was held down to a reasonable figure as shown by the following exhibit:

Men's Clubs

Club	Persons	Fall	Winter	Spring	Average
A	85	$3.12	$2.80	$3.20	$3.04
B	75	3.11	3.17	3.58	3.28
D	225	2.75	3.00	3.15	2.96
E	75	3.30	3.45	4.10	3.61
G	70	3.10	3.25	3.82	3.39

General average........$3.26

Women's Clubs

Club	Persons	Fall	Winter	Spring	Average
C	250	$2.80	$2.85	$3.45	$3.03
F	50	2.70	2.80	2.78	2.76
H	25	3.15	3.49	3.98	3.54
			General average	....	$3.11

THE PRUDDEN HIGHWAY.

One of the most important improvements of the year was the completion of one and seven-eighths miles of concrete highway reaching from Harrison avenue (the White Elephant corner) to the eastern limits of the City of Lansing where the brick pavement at present ends, at an expense of $25,000. This enterprise was fostered and largely financed by W. K. Prudden of the Class of '78. The work was begun in August, 1916 and completed November 30th.

The influence which such a highway has and will have in the future upon the growth and development of the College cannot be overestimated. The M. A. C. community will not soon forget what it owes to Mr. Prudden's successful efforts.

STUDENT LOAN FUND.

The fund for rendering emergency relief to young men has helped forty-five of our students to remain in college who might otherwise have been obliged to give up their studies. The fund itself is small compared to the good it accomplishes.

Provided for by funds derived from the blanket tax of two dollars per term paid by each student for the support of athletics and entertainments our students attended the following course:

Oct. 24.	The Mawson Motion Pictures with lecture concerning the Shackleton investigations of the Antarctic regions.
Jan. 23.	Professor Alfred Noyes, Cambridge University of England, Visiting Professor of English at Princeton University.
Feb. 6.	Frederick Palmer, European War Correspondent.
Mar. 6.	Professor A. M. Wenley, University of Michigan.
Apr. 15.	Concert by College Glee Club.
May. 16.	Concert by Minneapolis Symphony Orchestra.

STUDENT LITERARY SOCIETIES.

Two additional Literary Societies were organized during the fall term to meet the needs of our increased growth in numbers. The Orphic for men and the Letonian for women.

For several years past there has been much interest developed in the scholarship records maintained by the membership in the various societies. The following table compiled from the official records of the College Registrar gives the relative position of each of the twenty-three

societies (obtained by averaging the standings of individual student members):

Men

1917	
Dorian	2.051
Eunomian	1.9909
Hermian	1.9781
Delphic	1.8123
Forensic	1.7844
Trimoira	1.649
Hesperian	1.643
Ae-Theon	1.6255
Union Lit.	1.6252
Columbian	1.542
Ionian	1.5339
Phylean	1.5337
Phi Delta	1.5306
Olympic	1.4602
Eclectic	1.446
Athenaeum	1.445
Aurorean	1.4202

Women

1917	
Letonian	2.104
Ero Alphian	2.1019
Feronian	2.0518
Themian	1.9906
Sesame	1.906
Sororian	1.881

(The figures indicate *exact relative standing* of the memberships).

GEORGE E. LAWSON MEMORIAL.

Student at M. A. C. 1889-1891. Died February 15, 1916.

John W. Beaumont of the State Board, on October 10, 1916, as a memorial to his fellow classmate and life long friend, George E. Lawson of Detroit, transferred to the College an investment bond of $500.00, interest from which is to be annually awarded "for the best essay in English produced by a male student."

COMMENCEMENT.

The Baccalaureate sermon on May 27th was delivered by Bishop Theodore S. Henderson of Detroit. Text, "He Took a Towel."

Commencement address, June 1, by Dr. Samuel M. Crothers of Cambridge, Mass.: "The Place of the Expert in a Democracy."

TABLE OF NUMBER OF GRADUATES BY DIVISIONS.

Degree of B. S. in Agriculture	126
Degree of B. S. in Engineering	63
Degree of B. S. in Home Economics	52
Degree of B. S. in Forestry	10
Degree of D. V. M in Veterinary	6
Advanced degrees obtained by study in residence at M. A. C.	10
Professional degrees earned by proficiency in chosen line of work.	
Degree of M. Agr.	1
Degree of M. E.	1
Degree of Hort.	4
Degree of For.	1

HONORARY DEGREES.

Ray Stannard Baker, '89, LL. D., Amherst, Mass.
Charles William Garfield, '70, LL. D., Grand Rapids, Mich.
Edgar Albert Burnett, '87, D. Sc., Lincoln, Neb.
Arthur Burton Cordley, '88, D. Sc., Corvallis, Ore.
Clarence Preston Gillett, '84, D. Sc., Fort Collins, Colo.
Clarence Beaman Smith, '94, D. Sc., Takoma Park, D. C.

FUTURE PLANS.

The teaching force of the College remained at their posts during the most of the month of June immediately following Commencement. During this time several conferences were held by different groups of teachers discussing the general aims and work of the staff. An outline has been made of plans which I hope will lead to closer contact between the different divisions of our teaching force so that unity of action may be assured and that each one of us may feel that he is recognized as an integral part of M. A. C., and as such is responsible for the upbuilding of the College.

Congress passed February 23rd, 1917, an act to promote vocational education (Smith-Hughes Bill). The 1917 Michigan Legislature having accepted the terms of the grant May 5th, 1917, (Tufts Bill) created the "State Board for Vocational Education," which consists of the Superintendent of Public Instruction, the President of the State Board of Education and the Presidents of the University and the Agricultural College. This College will, therefore, be called upon to exert still greater efforts toward developing in Michigan's secondary and rural schools thorough instruction in elementary principles of agriculture. Additional funds provided by this act of Congress will permit the College to enlarge upon and develop more fully the work already so well under way—the result of the efforts of Professor French of our department of Agricultural Education.

EXPERIMENT STATION.

The report of the Experiment Station Director again indicates that there is a decided necessity for the expenditure of more money for ex-

perimental purposes by that division. Owing to the great variety of agricultural products grown in Michigan and the consequent increase in plant and animal diseases, there are strong reasons why more and more money for experimental investigations is much needed. The results obtained by our Experiment Station workers form the basis for all of our Extension work.

EXTENSION SERVICE.

This, under the Smith-Lever fund act was early recognized as a valuable adjunct to the work of the College as an educational institution and during the current year has proved of the greatest value in carrying forward the campaign for greater food production. The College, at the outbreak of the war, offered its services to Governor Sleeper to take charge of the campaign for the increase of food production but after being in conference with a number of prominent citizens of Michigan, Governor Sleeper thought best to place the matter of food production in the hands of a body of men known as the Food Preparedness Committee with which the Extension Service has cooperated. To attain the desired ends, funds were granted from the State Treasury on recommendation of this Food Preparedness Committee, the following named men were appointed as Emergency County Agents for the counties named. These men, in addition to the regular County Agents having permanent appointments under the Smith-Lever Bill, have assisted materially in the food production problem.

STATE AGRICULTURAL AGENTS FOR MICHIGAN

1917-18

County	Name and Address.
Alger	A. L. Olsen, Munising.
Alcona, Iosco	R. E. Prescott, Lincoln.
Antrim, Otsego, Montmorency	R. D. Bailey, Gaylord.
Barry	R. G. Brumm, Nashville.
Bay, Arenac	R. D. Harrison, Jr., Bay City.
Cass	W. D. Jones, Cassopolis.
Calhoun	E. B. More, Marshall.
Charlevoix	George Kilborn, Petoskey.
Clare	W. J. Kennedy, Clare.
Clinton	O. C. Hollister, Laingsburg.
Eaton	Fred Curtiss, Charlotte.
Genesee	J. F. Rieman, Flint, City Hall.
Grand Traverse, Kalkaska	M. E. Duckles, Traverse City.
Gladwin	U. R. Reynolds, Gladwin.
Gratiot	C. J. Chambers, Ithaca.
Hillsdale	Geo. B. Smith, Addison.
Huron	L. L. McCarty, Bad Axe.
Ingham	Frank Seeley, Mason.
Ionia	Arthur P. Loomis, Ionia, R. F. D. No. 3.
Isabella	Stephen S. Fall, Mt. Pleasant.
Jackson	E. C. Fowler, Jackson, Court House.
Lapeer	John W. Scully, Almont.
Leelanau, Benzie	A. W. Mebert, Suttons Bay.
Livingston	H. W. Norton, Howell.

Macomb	R. G. Potts, Washington.
Mackinac, Luce	M. A. Leach, Newberry.
Mecosta	B. J. Ford, Big Rapids.
Midland	H. W. Hock, Midland.
Monroe	J. B. Winslow, Temperance.
Montcalm	Edwin D. Greenhoe, Sheridan.
Oakland	Harry McCracken, Farmington.
Oceana	Bernie Beach, Shelby.
Osceola, Lake	C. L. Rose, Evart.
Roscommon, Crawford, Ogemaw & Oscoda	W. F. Johnston, Roscommon.
Sanilac	Grant Smith, Lexington.
Shiawassee	A. B. Cook, Owosso.
Tuscola	Alex. MacVittie, Caro.
Washtenaw	W. D. Underdown, Ann Arbor, Edison Bldg.

In conclusion I desire to express my great appreciation of the hearty cooperation I have received from the members of the State Board as well as my associates of the teaching staff of the College.

Respectfully submitted,

FRANK S. KEDZIE,

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEAN OF AGRICULTURE.

To President Kedzie:

I am submitting herewith a brief report because the heads of the departments of the Agricultural Division have furnished detailed information relating to their work. Progress made during the past year was very satisfactory to both faculty and students. Few changes took place in the personnel of our staff. Prof. V. M. Shoesmith resigned March 1st, to assume the management of a large farm estate and was succeeded by Prof. J. F. Cox who has been acting in charge since. Some additions have been made to the equipment for instruction work, laboratory courses have been more definitely outlined and the general efficiency of the instruction work greatly increased. A course in land drainage has been authorized by the faculty to be given jointly by Farm Mechanics and Soils departments, thus meeting a very pressing need.

The graduating class of the year receiving the B. S., degree, including general agriculture, horticulture and forestry, numbered 139. The following advanced degrees were awarded, viz.: Master of Science 13, Master of Agriculture 3, Master of Horticulture 4, Master of Forestry 1.

The following statement gives the enrollment in the four year courses in agriculture and forestry for the year, viz.:

Graduate Students	24
Seniors	150
Juniors	170
Sophomores	169
Freshmen	224
Specials	28
Summer Session	133
	898

Short Course Enrollment:

Two Year 16 Weeks Course, 1st year	82
Two Year 16 Weeks Course, 2nd year	53
General Agriculture, 8 Weeks, 1st year	82
General Agriculture, 8 Weeks, 2nd year	33
Horticulture, 8 Weeks	15
Dairying, 8 Weeks	24
Poultry, 8 Weeks	6
	295

The total enrollment for the Agricultural Division during the year, including both regular and short course students amounted to 1193, a slight decrease in comparison with the previous year. As all available space in the Agricultural Building was given over to the Engineering Division, no attempt was made to procure a large attendance upon Short Courses and the somewhat lesser numbers were handled with difficulty as it was.

The Short Courses were directed by Mr. Ashley M. Berridge in a very satisfactory way, in fact never before has there been such close personal touch between administration and student, nor have class nor individual needs been met in such a satisfactory way heretofore.

Dr. G. D. Shafer, Secretary of the Committee on Advanced Degrees, conducted the work of the year in an unusually painstaking and satisfactory way. We regret, exceedingly, that Dr. Shafer finds it impossible to remain with us another year and continue the work so satisfactorily performed by him.

Personally I have been engaged in instruction work during each term of the year, having presented the subject of Farm Management to Short Course men during the fall term and juniors in the spring, as well as meeting juniors in Animal Feeding and freshmen in Agricultural Development in the winter term.

I desire to express my appreciation of the persistent, painstaking, efficient efforts of Mr. R. S. Hudson, Superintendent of the College Farm, whose duties are of a more arduous character than is generally realized.

I greatly appreciate the support and continuance of the pleasantest relations with all with whom I am officially associated.

Respectfully submitted,

R. S. SHAW,

Dean of Agriculture.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF HORTICULTURE AND LANDSCAPE GARDENING.

To the President:

Sir—I herewith submit the following report of the Department of Horticulture and Landscape Gardening for the year ending June 30th, 1917:

The instructional work given during the year to all classes is briefly summarized below:

FALL TERM.

Subject.	Time.	Teacher.	Students Enrolled.
Horticulture 2	2 lectures 2 laboratory periods	Halligan Loree	191
Horticulture 4	3 lectures 2 laboratory periods	Eustace Halligan	38
Horticulture 7	3 lectures 2 laboratory periods	Eustace Loree & Gunson	40
Horticulture 10a	1 lecture	Eustace	42
Horticulture 11a	2 lectures 2 laboratory periods	Eustace Loree	27
Horticulture 12a	2 lectures 2 laboratory periods	Halligan	14
Horticulture 14	3 lectures 2 laboratory periods	Gunson	29
Graduate	Major election Minor election		2 2

WINTER TERM.

Horticulture 3	4 laboratory periods	Loree	154
Horticulture 5	3 lectures 2 laboratory periods	Gunson Halligan	43
Horticulture 8	5 lectures	Eustace	37
Horticulture 10b	1 lecture	Eustace, 29 Halligan, 14	43
Horticulture 11b	2 lectures 2 laboratory periods	Eustace Loree	27
Horticulture 12b	2 lectures 2 laboratory periods	Halligan	14
Short Courses in Fruit Growing	5 lectures 5 laboratory periods	France	24
Special Short Course, First year	16 weeks	Halligan	31
Special Short Course, Second year	8 weeks	Halligan	13
Housekeeper's Course		Halligan, Gunson	11
Graduate	Major elections Minor elections		2 2

SPRING TERM.

Horticulture 6	3 lectures 2 laboratory periods	Halligan	38
Horticulture 9	5 laboratory periods	Eustace, 25 Halligan, 10	35
Horticulture 10c	1 lecture	Eustace, 27 Halligan, 14	41
Horticulture 11c	2 lectures 2 laboratory periods	Eustace Loree	28
Horticulture 12c	2 lectures 2 laboratory periods	Halligan	14
Horticulture 13	3 lectures 2 laboratory periods	Loree	23
Graduate	Major election Minor election		2 1

SUMMER TERM.

Horticulture 2	Lectures, laboratory periods	Halligan	6
Horticulture 3	Lectures, laboratory periods	Loree	3
General Agriculture	2 weeks of Horticulture	Halligan	7

All of this teaching has been done by the regular instructors of the College with the exception of the Short Course in Fruit Growing which was given by Mr. J. G. France, a graduate of the College in the class of 1911 whom we were fortunate enough to secure for this work.

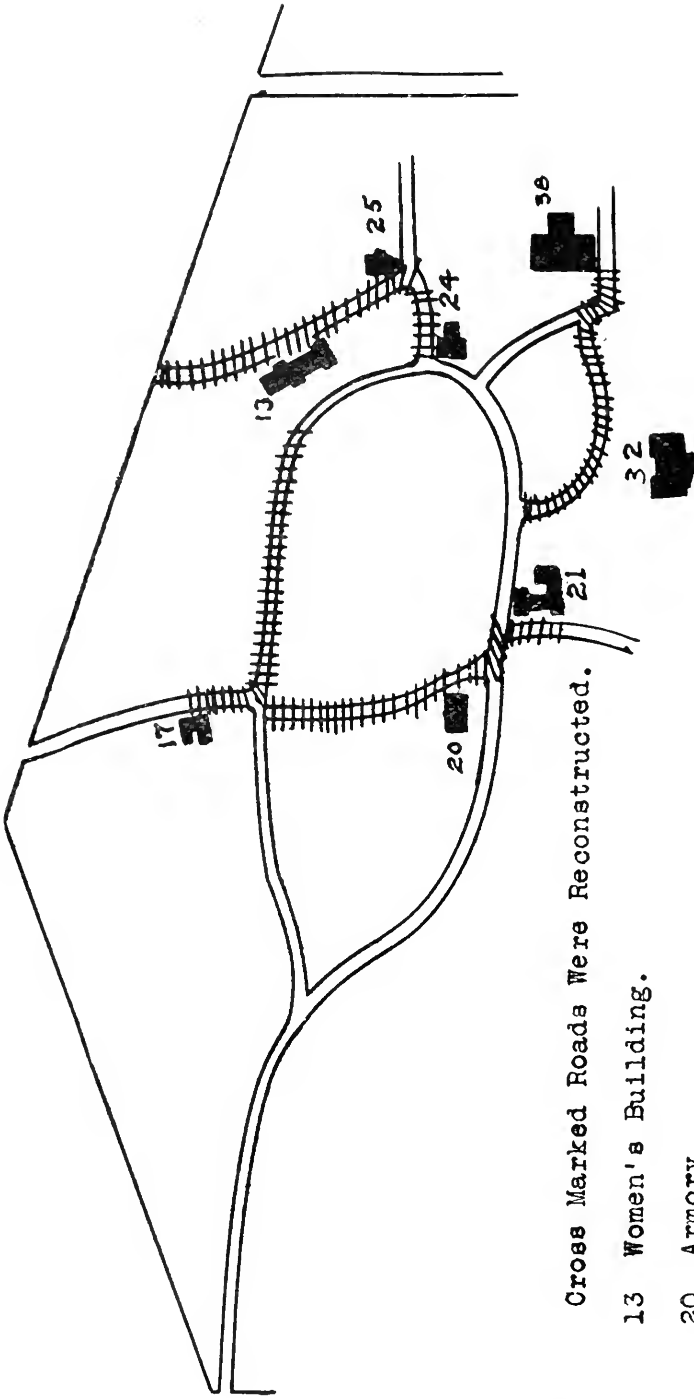
As the instruction work is now given, it includes a reasonable amount of work in the senior year in pomology and landscape gardening. Similar and parallel courses should be offered in floriculture and in vegetable growing. There is a definite and enlarging field for instruction in both of these subjects. However, before it is possible to give this work as it should be given, it will be necessary to have enlarged facilities in laboratory quarters and particularly in the greenhouse. Both the floriculture and vegetable gardening interests in this state are very large and constantly growing more important. Students who are anxious for instruction in these lines of work, and there is an increasing number every year, are obliged to go to neighboring institutions for advanced courses in these subjects. It is sincerely hoped that at the earliest possible moment provision can be made to offer courses in these lines.

During the past summer and fall, the basement room in the laboratory has been overhauled, enlarged and equipped with working tables which are supplied with gas, water and drainage. The equipping of this laboratory is going to afford considerable relief in handling some of the large classes but there is still a serious lack of work room in the laboratory for many of the classes and a particularly serious handicap on office room. With the increasing number of men in the Experiment Station and Extension work, the quarters are very uncomfortably crowded. A new laboratory building is certainly a very much needed part of the equipment. The present building is now twenty-nine years old and at that time cost but $7,000.

Since it is highly desirable to do so much of the instructional work in the greenhouse, the lack of space there is keenly felt, and through the demands made upon the department for flowers and plants for decorative purposes at many College functions, the inadequacy of the greenhouse equipment is more keenly realized than ever. A range of modern houses is still hoped for.

The work of keeping the campus attractive and tidy is becoming more serious and more expensive to handle every year and probably will continue to be so owing to the increased automobile traffic from Lansing and vicinity and the growing population of East Lansing and the vicinity of the College. During the summer, a great deal of money and time was expended in improving the campus roads and just the amount of improvement that was done is shown on the accompanying diagram.

All the work was done under the personal supervision of Professor Thomas Gunson by the regular department workmen and all expenses were paid out of the department appropriation. The method was to excavate the old roadbed to an average depth of twelve inches which was then filled with nine inches of stone salvaged from the superstructure of the Engineering Building. This filling was covered with two inches of broken stone and brick and on this was placed one inch of road gravel and then thoroughly rolled with a sixteen ton road roller. Wherever the road bed was clay, ample provision was made for drainage to prevent heaving in the spring.



Cross Marked Roads Were Reconstructed.

13 Women's Building.

20 Armory.

24 Library.

25 Horticultural Laboratory.

38 Agricultural Building.

The effort to keep enlarging the species of trees and shrubs on the campus is continually being made and it is the constant desire to have the campus of educational value as well as attractive in general appearance.

In the orchard and garden work, new plantings have been made of various fruits, particularly the new kinds, and a constant effort is being made to improve these grounds along educational lines although the effort to produce the various kinds of fruit in so close proximity to a populated city is increasingly difficult.

It is suggested that it would be desirable for the State Board of Agriculture to employ a man to police the gardens and grounds.

It is a pleasure and satisfaction to acknowledge the interest of the officers and members of the Michigan State Horticultural Society in the students of horticulture. As has been noted in previous reports, the Society offers two contests open to horticultural students of the College, one for a five minute speaking contest and one for fruit judging and identification. The prizes are thirty dollars for each contest, divided into $15.00, $10.00 and $5.00.

In the speaking contest, the winners were:

Mr. A. L. Pino, Ithaca, Michigan—First.
Mr. R. L. Lepper, Washington, D. C.,—Second.
Mr. J. T. Bregger, Bangor, Michigan—Third.

In the fruit judging and identification:

Mr. E. B. Benson, Fennville, Michigan—First.
Mr. J. F. Sheldon, Croswell, Michigan—Second.
Mr. W. F. Van Buskirk, Erie, Pa.,—Third.

The Ninth Annual Fruit and Flower Show was held during the latter part of January. This was handled entirely by the junior and senior students specializing in the department and was a splendid success and enjoyed not only by a large number of college students but by residents of East Lansing and Lansing.

The shortening of the spring term so that all work closed on the 31st of May necessitated the decided curtailment of the work planned for the various courses but the best was made of this situation.

It is a pleasure to report the loyalty and interest of all members of the department: Associate Professor C. P. Halligan; Assistant Professor Thomas Gunson; Instructor R. E. Loree; Extension Specialists C. W. Waid and J. H. Carmody; Assistant Horticulturists W. C. Dutton and H. J. Bock and Miss Nellie Strudley, Clerk.

Respectfully submitted,
H. J. EUSTACE,
Professor of Horticulture.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF DAIRY HUSBANDRY.

President F. S. Kedzie, East Lansing, Mich.

Dear Sir:—In reviewing the college year ending June 30, 1917, we have the honor to present the following facts and observations as worthy of especial notice.

With the more active interest in dairying and the increasing number of students attending college, an even larger number of men are taking the dairy courses than was anticipated when the present Dairy Building was constructed. While the building is of ample size for dairy manufactures, it has been found impracticable to separate the students into a sufficiently large number of sections to enable them to take the courses in manufacture with greatest benefit. To alleviate this condition and to distribute the teaching more evenly throughout the year, as well as to make the dairy plant constantly effective, Dairy Husbandry 2 and Dairy Husbandry 3, have been scheduled for three terms during the year; namely, the fall, the spring, and the summer terms. Dairy Husbandry 1, and Dairy Husbandry 4, which occur in the spring term, are also offered in the summer term. It is anticipated that these arrangements will bring needed relief.

Each year an increasingly large number of students have asked for a course in ice cream making. This has been added during the past year, and will be offered both in the spring and in the summer terms. The work of this subject is being placed on par with that of the other dairy courses.

It is more than probable that a further re-arrangement will be asked for during the coming year, which will permit the department to give a course in dairy production.

As intimated in my last annual report, the Creamery Buttermakers' Conference and Six-day School has been made an annual feature, and the week next preceding the Christmas vacation has been assigned as the regular time for holding this school. During the last session the school was attended by over fifty people, forty-two being buttermakers or creamery inspectors. Besides the regularly employed instructors of this department, Professor M. Mortensen of Ames, Iowa, was secured for the week, and gave most valuable assistance.

The further investigation into the Cost of Milk Production has been continued throughout the year, Mr. F. T. Riddell being in general charge of the work. Mr. A. C. Lytle has been stationed at Webberville, and Mr. S. J. Brownell has acted in a similar capacity at Howell.

During the last year the results of the Grand Rapids investigations have been compiled and published as Bulletin No. 277.

The first report of the work at Howell and Webberville will be ready for publication in a very short time, and is now being compiled by Mr. Riddell.

During the year the department has been most ably assisted by Professor H. E. Dennison in the field of Dairy Production, Professor C. E. Newlander in the field of Dairy Physics and Chemistry, Mr. W. D.

Meltzer as instructor in Butter making and Ice Cream making, Miss Alison Ransford as instructor in Cheese making, Mr. John E. Burnett as instructor in Dairy Production and as Supervisor of Advanced Registry tests, Mr. R. W. Wyant as instructor in Market Milk Management, and Mr. F. A. Hagedorn as Assistant in Butter making.

Mr. Meltzer resigned March 1st to take a position with a creamery company in Canada, and his place has been filled by Mr. F. A. Hagedorn. Professor H. E. Dennison resigned April 1st to take up farming in the state of New York. Professor C. E. Newlander resigned June 1st to take up extension work with the Dairy Division of the United States Department of Agriculture.

We are pleased to report that instruction has been given in all the courses of study offered to regular as well as to special students. It is our opinion that the character of the instruction and work accomplished by the students has been fully up to standard, and it has seemed in some ways that we have even done better work than heretofore.

Respectfully submitted,

A. C. ANDERSON,

Professor of Dairy Husbandry.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF FARM CROPS.

President F. S. Kedzie, East Lansing, Mich.

Dear Sir—I submit herewith a brief report of the work of the Department of Farm Crops for the year ending June 30, 1917:

Professor V. M. Shoesmith, head of the department, resigned April 1st to take over the management of a large tract of land near Grand Rapids. His departure was marked by the regret of the entire department, and hearty good wishes for success in his new field.

A brief summary of courses, number of students enrolled, and instructors in charge, is herewith given:

Farm Crops I, Cereal Crops, Freshman Course....216 students
J. F. Cox.
Farm Crops II, Forage Crops, Sophomore Course ..148 students
A. L. Bibbins.
Farm Crops III, Grain Judging, Senior Course ....68 students
V. M. Shoesmith, J. F. Cox, A. L. Bibbins.
Farm Crops IV, Special Mich. Crops, Senior Course..78 students
J. F. Cox, A. L. Bibbins.
Farm Crops V, Crop Improvement, Senior Course...72 students
F. A. Spragg, Graduate Assistant Putnam.
Graduate Students 2

During the summer session, Farm Crops IV was presented, and a special two weeks crops course for rural teachers.

Two crops courses were given during the winter to the two year Short Course students, and two to the eight weeks Short Course students.

The declaration of war with Germany increased, rather than decreased, interest in the spring courses. Members of the class prepared numerous articles on timely crops subjects for publication in their home papers, accompanied by personal letters. A number enlisted in the Officers' Training Camp, returned to the farm, or took up constructive agricultural work in the state toward the end of the term.

Special attention was given in the spring to the planting of instructional plats used as a basis for study in the field of various crops, and to furnish an ample supply of crops material for class room and exhibit purposes.

Provision is made in all courses given by the department for laboratory and field work, except in Farm Crops II, and it is hoped that satisfactory arrangements will be made to strengthen this course by proper laboratory work before it is again repeated.

As rapidly as possible, crop samples, exhibits, and illustrative material are being added to the collection of the department to further strengthen the teaching work.

Owing to the hearty cooperation of all in the department, I take pleasure in reporting progress for the last year.

Very truly yours,
J. F. COX,
Acting Head, Department of Farm Crops.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF SOILS.

President F. S. Kedzie, Michigan Agricultural College.

Again it is gratifying to report favorably upon the progress of the departmental activities. As predicted in last year's report the courses offered by the various members of this department were made somewhat stronger than previously, yet our plans for the ensuing year are such that greater efficiency should result.

The department has received a few requests from other institutions for men to take up college and station work, invariably men of thorough training in the sciences being sought. It is unquestionably true that the importance of a working knowledge of these subjects is being more strongly emphasized than previously. We again desire to lay emphasis on this phase of the educational activities of the institution, being firmly convinced that students should be encouraged to thoroughly ground themselves along these lines. Moreover, the time has doubtless passed when a student is able to master all phases of agriculture together with the necessary courses in other lines, in four years. In fact, we are rapidly coming to the conclusion that students are required to scatter their energies in too many directions and that slight changes could be made that would result very favorably.

During the year extension work was conducted by means of correspondence; a few lectures to institutes and in addition, about five hundred samples of soil and marl were examined and reported upon.

We also cooperated with certain county agricultural agents. In this connection it is well to state that we have found it indeed desirable for those in charge of the various classes to come in contact with, and study the soil conditions in the state.

Mr. C. W. Murphy conducted several one week schools during the winter; reports that came to my attention show that this phase of the extension activities is in great demand in several sections of the state.

The enrollment in the various courses offered was as follows:

Soils 2 A	176
Soils 2 B	165
Soils 4 A	33
Soils 4 B	47
Soils 4 C	48

Respectfully yours,
M. M. McCOOL,
Professor of Soils.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF ANIMAL HUSBANDRY.

President F. S. Kedzie, College.

Dear Sir—I have the honor to submit the following report of the Department of Animal Husbandry for the year ending June 30, 1917.

Schedule of class work given by department staff during the year:

Class.	Subject.	Section.	Teacher.	Hours per week.	Students enrolled.
Freshman	Animal Husbandry 1	1-3	Mr. Clark	6	72
Freshman	Animal Husbandry 1	4-6	Mr. Clark	6	59
Freshman	Animal Husbandry 1	7-9	Mr. Edwards	6	59
Freshman	Animal Husbandry 1	10-12	Mr. Edwards	6	55
Junior	Animal Husbandry 2		Mr. Edwards	6	132
Senior	Animal Husbandry 5		Prof. Brown, Mr. Clark	15	(one half term) 53
Two year Short Course (1st term 2nd year 16 weeks)	Study of Types		Prof. Brown	10	87
Two year Short Course (1st term 2nd year 16 weeks)	Stock Feeding		Prof. Brown	5	87
				52.5	604

Average enrollment per class, 75.5.
Average enrollment per instructor, 201.

WINTER TERM.

Class.	Subject.	Section.	Teacher.	Hours per week.	Students enrolled.
Junior	Animal Husbandry 4		Mr. Edwards	5	143
Senior	Animal Husbandry 6		Prof. Brown	6	30
Senior	Animal Husbandry 6		Prof. Brown	6	29
Two Yr. Short Course (16 weeks)	Study of breeds		Mr. Edwards, Mr. Clark	10	74
Two Yr. Short Course (2d Yr. 16 Wks.)	Stock Judging		Mr. Edwards	6	53
Two Yr. Short Course (2d Yr. 8 Wks.)	Stock Judging		Mr. Clark	6	38
Two Yr. Short Course (1st Yr. 8 Wks.)	Types and Breeds		Mr. Clark	6	81
Two Yr. Short Course (1st Yr. 8 Wks.)	Animal Feeding		Mr. Edwards	5	49
Two Yr. Short Course (1st Yr. 8 Wks.)	Animal Feeding		Mr. Clark	5	31
				55	528

Average enrollment per class, 88.
Average enrollment per instructor, 176.

The instructional force during the past year consisted of Mr. W. E. J. Edwards and Mr. W. N. Clark, both of whom performed very satisfactory work. Mr. Clark resigned March 1st to accept a position as Farm Manager at Glenview, Illinois.

I would especially direct your attention to the fact that the average number of students per class handled by the department was 75 during the fall term and 88 during the winter term. Again, there was in the fall term over 200 men enrolled in classes for each member of the teaching force and in the winter 176 men for each member of the teaching force. When it is remembered that these averages include the seniors who are receiving technical work and are specializing in the subject of Animal Husbandry it at once becomes apparent that they are not receiving the attention which is rightfully theirs, nor is it possible to do the class of work that a college should stand for, with classes of the above size.

During August, September and October, members of the department judged live stock at the following fairs: Detroit, Grand Rapids, Bay City, Howell, Owosso, St. Johns, Saginaw, Greenville, Harrison, Evart, Marshall, Emmet City, Big Rapids, Hastings, Cadillac, Adrian, Hillsdale, Jackson, Caledonia and Wolverine. It is regretted that more time cannot be given to fair judging as this work brings the members of the staff in close touch with the live stock breeders of the state and gives them an insight into live stock conditions that could be obtained in no other way.

Care and management of the live stock equipment handled by the department has been greatly facilitated and placed on a much more economical basis since the appointment of Mr. Robert Mackie, January 1st, to have charge of the herds and flocks. At the present time the department maintains breeding herds of six different breeds of swine, four different breeds of cattle and breeding flocks of seven different breeds of sheep. The large number of breeds are maintained to furnish instruction to the students through first-hand experience and handling of the animals rather than through text-book knowledge. The breeding herds and flocks have been built up on a very slight expenditure of money and are now in first-class condition, although if their improvement is to be further continued, it will necessitate the expenditure of larger sums for the purchase of high-class sires.

Respectfully submitted,
GEO. A. BROWN,
Associate Professor of Animal Husbandry.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF POULTRY HUSBANDRY.

President F. S. Kedzie, College.

Dear Sir—I have the honor to submit the following report of the Department of Poultry Husbandry for the year ending June 30, 1917:

BUILDINGS.

We are occupying seventeen buildings; one house 18 ft. by 184 ft, one house 16 ft. by 84 ft., three colony houses each 16 ft. by 24 ft., two colony houses 6 ft. by 8 ft., seven portable colony houses 10 ft. by 12 ft., one open front house 20 ft. by 20 ft., and an oat sprouting house 10 ft. by 14 ft. Students have built three houses as laboratory work during the year.

EQUIPMENT.

The department has operated eighteen incubators, one 1200 egg size, two 200 egg size, three 150 egg size and twelve 70 egg size. Students have received instruction in handling all methods of heating in incubators—lamp, water and electricity. One large laying house has been converted into a brooder house with ample facilities for brooding 3500 young chicks with the colony stove system. Eighteen lamp brooders are available that will brood 1300 young chicks so that the total brooding capacity for the poultry plant is 4800 young chicks.

Breeds of fowls that are popular with farmers, poultrymen and backyard raisers of poultry are maintained upon the poultry plant. Ducks, geese and turkeys are also kept for educational and investigational purposes.

Table showing the kinds of fowls:

Hens	840
Cockbirds	57
Young stock (all ages)	2100
Turkeys	3
Ducks (Rouen) old	15
Ducks (young)	40
Geese (old)	8
Geese (young)	12
Total	3075

The instruction work for the year has been as follows:

Summer Term—5 regular students, 15 special students, Total—20.
Fall Term—9 regular students, Total—9.
Winter Term—17 regular students, 33 S. Course, Total—50.
Spring Term—137 regular students, Total—137.

Total for the year	216
Total number of hours devoted to lectures	150
Total number of hours devoted to laboratory work	267
Total number of hours of instructional work	417

The following investigational work has been started:

1. Testing simple and complex rations for laying hens.
2. Testing effect of open front housing for laying hens.
3. Testing hatchability of eggs kept for different lengths of time.
4. Testing moisture problems in incubators.
5. Testing effect on hatchability of eggs layed by hens fed upon beef scrap, buttermilk and cottage cheese.
6. Comparison of length of time for incubation of brown and of white eggs.
7. Testing effect of artificial lighting of laying houses upon egg production and vitality of chicks hatched from eggs laid under these conditions has been continued.

Trap nesting and pedigreeing stock has been carried forward.

Every possible effort is being made to bring the flock up to the very highest egg and meat producing power.

Respectfully submitted,

C. H. BURGESS,

Associate Professor of Poultry Husbandry.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF FARM MECHANICS.

President F. S. Kedzie, College.

Dear Sir—I have the honor to submit the report of the Department of Farm Mechanics for the year 1916-17.

INSTRUCTION.

Following is given the staff of instructors and assistants whose whole-hearted support and cooperation in the work of the department I wish to acknowledge:

Mr. Wilson Duncan was appointed instructor in blacksmithing, January 1st, and has carried on this work very satisfactorily, in addition to the horseshoeing and repair work.

We are indebted to the Engineering division for the services of Mr. A. Watt, whose time and effort was unreservedly given for the Short Course work in blacksmithing.

Mr. C. N. Rix continued with his work of instructing the Short Course men in wood shop and worked out a set of new practical exercises for them.

Mr. H. J. Gallagher assisted in the wood shop work and gave valuable aid.

Mr. D. H. Flower taught Farm Engineering and Creamery Mechanics and gave much practical help in the development of marl handling machinery.

Mr. O. E. Robey, Extension Specialist in Household Engineering, has had greatly increasing interest shown in his work, especially in the counties where the work was carried on previously.

Mr. Samuel Toms has continued in charge of the machinery laboratory.

Instruction in the several courses given by the department may be summarized. The number of students receiving work is as follows:

Farm Structures	60
Farm Conveniences	24
Power Machinery	99
Farm Machinery	43

In the short courses the numbers are:

Building Desiguing	53
Farm Engineering	50
Wood Work	147
Forge Work	148
Creamery Mechanics	19
Gas Engines (Horticultural)	13

Practical work was done by the class in Farm Conveniences. One of the problems worked out was the construction by the class of a concrete manure pit for the Bacteriology department barns. A new and much needed course in Farm Drainage is to be added next year. This course will present work which is of particular interest on the farm considered as a unit.

INVESTIGATION.

Many inquiries concerning methods of removing marl from submerged beds has brought this problem to our attention. Some thought has been given the problem for two years or more. Last spring, however, the interest in this was greatly increased, and Mr. D. H. Flower was engaged to work on the problem. No practical results have been attained as yet.

Much valuable information is still being collected by the Extension Representative in Household Engineering on sewage disposal. An effort has been made to keep in touch with tractor development. There are now one hundred and fifty different sizes and types of tractors to be had, though none have proved their place in more than a limited way.

EXTENSION.

The work in Extension has been confined quite closely this year to Household Engineering, a report of which is made under the Extension division by Mr. O. E. Robey who has had charge of this work. With the call for greater production last spring, the work in Household Engineering was reduced and work in drainage taken up. The interest in drainage has increased wonderfully and provision should be made to meet this increasing demand. About 250 sets of blue-prints on various subjects principally barns and other farm buildings have been sent out besides those handled by the Extension representative. Greater demands are being made on the department for information and great opportunities are ahead if these demands can be met.

Respectfully submitted,

H. H. MUSSELMAN,

Associate Professor of Farm Mechanics.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF AGRICULTURAL EDUCATION.

To the President.

Sir—I herewith submit a brief report of the work of the Department of Agricultural Education during the year ending June 30, 1916.

I. TEACHING.

During the summer school of 1916, I had charge of two double period classes, one in elementary rural education and the other in agricultural pedagogy.

During the school year I have given courses in pedagogics for both men and women. The courses given to the women are known as Pedagogy I, II and III. The number of women taking these courses has averaged fifty-five during the year. The courses given to the men are known as Pedagogy IV, V and VI. In the fall term I had 145 students in these subjects and in the winter term 117 and in the spring term 118. There were two sections for the men, with about an equal number in each section. In connection with the class room instruction the young women are required to observe instruction in domestic science and art in the public schools, and for this purpose they visited the leading schools within a reasonable distance of Lansing, teaching these subjects. The women are also required to have practical exercises in school sanitation, schoolhouse construction and arrangement, particularly with reference to the laboratory for domestic science and art, also school room decoration and extension service in home economics in the public schools. The men are required to observe instruction in agriculture in high schools where agriculture is taught and to submit written reports upon their visit concerning the science work and agricultural work, with a description of laboratories, laboratory equipment and the organization of field work for high school students.

II. HIGH SCHOOLS.

During the year four year courses in agriculture have been given in fifty-seven high schools. The instructors in all these schools are graduates of this institution or of other agricultural colleges. In addition to these schools there are about twenty other high schools giving some agricultural instruction, the instructors being men who have had short courses in college or agriculture in a normal school. All these high schools have been inspected by Mr. Grover, of this department, and by myself. During the spring of 1917, I have organized ten new high schools for courses in agriculture as follows:—Albion, Flint, Gladwin, Highland Park, Ionia, Lowell, Manistique, Portland, Sandusky and Three Rivers. Unless some of the teachers of agriculture are drafted into the army we shall have sixty-seven high schools teaching agriculture and the instruction given by agricultural college graduates, for the ensuing year. The same standards of work and equipment as were established last

year have been required for this year, and these standards constitute the basis for recognition of the agricultural work for entrance credit at the University and other educational institutions.

During the year we have developed the practical side of the agricultural instruction by organizing a high school agricultural association in each high school where agriculture is taught. The members of this association agree to work out practical farm projects during the summer season and make a report upon same to this department, as well as to their schools. The supervision of this project work has been placed in charge of Mr. E. Lynn Grover, Assistant Professor of this department.

III. EXTENSION SERVICE.

I have conducted five teachers' institutes during the year and have given a number of addresses at farmers' meetings in different parts of the state. I have also cooperated with the Department of Public Instruction in the matter of re-organizing the rural schools. We have given especial attention to the matter of organizing township districts and township high schools. We have had frequent meetings with groups of County Commissioners of schools, and during the Farmers' Week at the College we invited all the Commissioners of the state to attend the special rural educational convention at the College. The proceedings of this convention proved to be so pleasing that the Commissioners requested another meeting of the same type to be held during the ensuing year.

IV. PUBLICATIONS.

During the year we have published two pamphlets: First, bulletin No. 16, which is a report to the College and to the state on instruction in agriculture in secondary schools. Second, bulletin No. 17, which is an outline of the plan for organizing the high schools for home project work. The bulletin contains a full description of this work, with suggested credits to be given by the schools for such field work.

V. TEACHERS.

Not all the young men, who take the courses in pedagogics intend to teach, only about 40% of the young men from the agricultural courses were prepared for teaching. The war conditions have interfered materially this year by taking a large number of men in the agricultural course for special farm work and for military service, thus reducing the possible number of men open to employment as teachers of agriculture.

We have a regular system of registration for those who intend to teach and we keep in constant touch with the work of the public schools and render such service to superintendents of schools and Boards of Education as they may desire in the matter of securing teachers for special subjects in domestic science and art and agriculture. We have been able also to locate a number of our men as teachers of manual training and teachers of science. Up to this time this year, we have located nineteen men as teachers of agriculture and twenty women as teachers of domestic science and art. Thus far we have been able to supply all the calls for such special teachers that came to us. About half of the schools of the state, which teach domestic science have em-

ployed our women as instructors. So far as I can see at the present time, we shall be able to supply all the teachers of agriculture that may be needed for instruction in the public schools.

VI. THE STATE SOCIETY FOR THE PROMOTION OF AGRICULTURAL EDUCATION.

This society was organized in 1909 and consists of the teachers of agriculture, superintendents of schools, county school commissioners and others who are interested in the extension of agricultural education. This society held its annual meeting at the Agricultural College, the last meeting being held on May 4th and 5th.

Last fall at a meeting of the State Teachers' Association in Grand Rapids a section of the State Association was organized known as the section of Agricultural Instruction. This is the first time in the history of the state that the State Assocation has recognized officially the instruction of agriculture in the public schools. The officers for the current year are—Chairman, W. H. French, East Lansing; Secretary, Glen I. Hobbs of Three Rivers.

The State Association, which met at the College on May 4th, 1917, presented a very able program, but gave particular attention to a discussion of the Smith-Hughes law relating to Federal aid for instruction in agriculture and home economics. The officers elected for the ensuing year were: President, Geo. Gilbert of Gladwin, and Secretary L. R. Service of Monroe.

VII. VISITATION AND SUPERVISION OF SCHOOLS.

In addition to the instruction along the line of teacher training, which is assigned to the Department of Agricultural Education, the department has a man supervise the instruction in agriculture in the high schools of the state. The fifty-seven schools, which have been giving such instruction during the past year have been visited from one to three times, all of them have been visited once and many of them two or three times. In these visitations we observe the work and make suggestions and recommendations to the superintendent and instructor concerning text books, library equipment, field work and other things, which may tend to improve the character of the instruction and make it more effective.

We receive a cordial welcome from the superintendents of schools and I believe that this supervision work is of direct importance to the Agricultural College, as through it we come in contact with the public schools and secure instruction favorable to the institution that probably could not be secured in any other way and I believe this to be of distinct advantage to our institution.

VIII. ASSISTANT OF AGRICULTURAL EDUCATION.

I cannot speak too highly of the work of Mr. E. Lynn Grover, Assistant Professor of Agricultural Education. I consider him one of the strongest men in this line in the country. He has been untiring in his efforts to supervise and improve the character of the agricultural instruction in the high schools, and I have placed the development of the home project work wholly in his hands. This work is going forward vigorously

at the present time. It is no small task to travel from one end of the state to the other inspecting high schools, acting as judge at school fairs, speaking on agricultural education and cooperating with the instruction department of the College and at all points of contact, and I am pleased to say that Mr. Grover has measured up to the full standard in all this work.

We are now waiting anxiously for action by the Federal Board of Control, concerning the operation of the Smith-Hughes act and the State Board of Control for the same purpose within the state, as they will operate under the supervision of the Tufts law. These two laws afford Federal and State subsidy for agricultural education in the public schools and we believe that when these laws have been put in operation they will prove to be a strong stimulus to the work and will assist materially in standardizing the instruction, equipment and organization of this important branch of modern education.

Respectfully submitted,
WALTER H. FRENCH,
Professor of Agricultural Education.

East Lansing Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF FORESTRY.

The President, Michigan Agricultural College.

Sir—I have the honor to submit the following report for the Department of Forestry for the year ending June 30, 1917.

The work of instruction has been carried on during the year as described in the College catalog. The vacancy caused by the resignation of Mr. S. V. Klem, Instructor in Forestry, at the end of last year was not filled and the classes which had formerly been taught by him were taken by Professor Sanford and myself.

The Forestry Summer School was held as usual on the lands of the Cummer-Diggins Company at Dayhuff Lake near Cadillac. A short course in forestry, open to special students, was given this summer in addition to the regular work. The keynote of the special courses was the conservation of the natural resources of the country and the work was principally carried on in the woods near camp. A chapter of Xi Sigma Pi, a forestry honorary society, was organized at the College. It is already in a healthy condition and should do much toward raising the scholastic work of the students. The Forestry Club has been active during the year, the attendance during the fall and winter terms being particularly good. The second number of the Forestry Annual was published by the Club.

Ten men received the degree of B. S. in Forestry at Commencement. Of these two left College early in May to go to the Officers' Training Camp at Fort Sheridan, one was excused from classes at the same time to take special military training at Washington and one enlisted in the Lansing battery. The others obtained positions in forestry work immediately upon graduating.

Mr. E. G. Hamlin was appointed Half-time Graduate Assistant in Forestry in September and resigned in May to go to the Officers' Training Camp at Fort Sheridan. While connected with the College he began a very complete series of experiments on the control of damping-off of coniferous seedlings, which may be easily completed and will be of value, as this is a disease which does much damage each year in forest nurseries.

The appointment of Mr. E. C. Mandenberg as Extension Specialist in Foresty in September greatly relieved the strain upon the department in attempting to carry on the teaching and field work at the same time. An increasing number of calls for assistance in forestry work are coming in and with Mr. Mandenberg's assistance excellent service is being given.

The maple sugar bush in the River Woodlot was operated successfully, about seven hundred trees being tapped. The experimental work in the sugar bush was continued for the third year. After one more season's run sufficient data will have been collected to warrant publication of the results. The experimental work with basket willows was also continued. The size of the College willow holt was considerably increased and a large number of cuttings have been furnished at cost to residents of the state.

The Forest Nursery has been operated successfully, planting stock amounting to 95,000 trees having been shipped during the year. A large number of these trees have been used for sand dune planting, which work has been pushed by the department. Owing to depredations by one of the poplar borers it became necessary to destroy all the small Carolina poplars in the nursery, approximately 10,000 small trees being removed.

The planting experiment in cooperation with the United States Forest Service on lands adjacent to the College lands near East Tawas, which was started on a small scale last year, is being continued.

The department has given up a number of rooms to the Physics department. The work of the department is necessarily somewhat handicapped by the resultant crowding and it is hoped that the space may be restored within due time.

Respectfully submitted,
A. K. CHITTENDEN,
Professor of Forestry.

East Lansing, Mich., June 30, 1917.

REPORT OF SUPERINTENDENT OF FARMERS' INSTITUTES.

During the past year Farmers' Institutes have been held in all of the counties in the Lower Peninsula except Kent, as well as in most of the counties in the Upper Peninsula. With a few exceptions the county institutes, which were held at the end of the series, lasted two days, usually with five sessions, but in a few instances one-day meetings with two or three sessions were held, and in a number of other counties the institutes lasted three days generally with eight sessions. In this series there were 67 institutes, with 334 sessions and an attendance of 41,271.

For these meetings three speakers were generally furnished for at least one day. The third speaker was usually a woman who conducted a special congress for women. Instead of having a single session as has been customary in former years, a forenoon as well as an afternoon session was arranged.

ONE-DAY INSTITUTES.

The large demand for one-day institutes showed an increased interest in such meetings and the invitations were accepted so far as the funds available permitted. While a considerable number of counties held from twelve to eighteen institutes, the average number was only about six to a county. The holding of these meetings made it possible to place an institute within driving distance of a very large proportion of the farmers of Michigan and, in some counties, it was noted that a considerable number of farmers made it a practice to attend two or more of the institutes.

In most of the counties we were able to carry out the plan inaugurated some ten years ago of requiring the local associations to look after the entertainment and transportation of the state institute lecturer while in the county. This resulted in lessening the cost of holding the institutes by nearly one-half, the effect being to practically double the number of institutes that could have been held with the same funds had all of the expenses of the speaker been paid by the Agricultural College.

The success of these meetings was measured very accurately by the efficiency of the officers of the county institute societies. When care has been taken in the selection of these officers and they are not only efficient but able and willing to devote the time required for arranging and advertising the institute, it is very seldom that the meetings are not successful.

WOMEN'S CONGRESSES.

For nearly all of the county institutes held in the Lower Peninsula a woman speaker was furnished and in 53 counties a special women's congress was arranged. In several of the counties forenoon as well as afternoon sessions were held. A standard form of program was prepared and was used at practically all of the meetings. For the afternoon session the state speaker was generally assigned the topic, "The Use

of Eggs in the Diet." The lecturer took up not only the different methods of preparing eggs but also gave especial attention to the consideration of the food value of eggs. Although it was in a measure incidental, the food value of milk in the diet was also considered in connection with the use of milk and eggs in certain dishes. The lecturers were furnished with mimeograph outlines giving directions for the preparation of eggs in various ways; and also for the preservation of eggs. These outlines were supplied to those in attendance at the meetings.

The topic most generally used by the local speakers at the afternoon sessions of the women's congresses was, "The Selection and Care of Household Utensils." The choice of topics was generally very satisfactory and the ladies to whom the topic was assigned at the various institutes handled it very creditably. Many valuable suggestions and helpful ideas were brought out especially where they were able to secure exhibits of utensils not commonly found in farm homes.

COOPERATING WITH COUNTY AGENTS.

In the counties having county agricultural agents the locating and arranging of the institutes was left in their charge and, in most cases, the lecturers were the agents in neighboring counties, who had arranged for an exchange of services. Thus, the speakers at the one-day institutes in Van Buren county consisted of the county agents in Allegan, Berrien and Kalamazoo counties for each of whom the Van Buren county agent attended an equal number of institutes. In addition to a considerable saving in the cost of holding the institutes this system of exchanging speakers has many valuable features. We feel however that when a dozen or more institutes are held in a county it is asking too much of a county agent to attend these meetings and an equal number in other counties, especially when a number of extension schools are held. Not only does it interfere seriously with the regular work of the county agent to be called upon to devote five or six weeks during the winter to attending institutes and similar meetings, but he is not able to give the necessary attention to arranging for and advertising the institute meetings in his own county. This is shown by the appended table of statistics giving the attendance at the meetings in the different counties, since the number present at the one-day institutes in 1916-17 in the counties which do not have a county institute showed a considerable increase over the average for the previous five years. On the other hand, the attendance at the one-day institutes in counties having an agricultural agent shows a marked decrease in the average attendance per session.

In the Upper Peninsula the direction of the institutes has been in charge of Mr. J. Wade Weston, Assistant Leader of Farm Agents for that section, and the meetings have been carried on by Mr. Weston and the county agents through exchanges similar to those made use of in the Lower Peninsula. The attendance reported is not an accurate index of the interest and attendance, since instead of there being only one session at most places as is shown by the attendance reported, the remainder of the day was spent in giving demonstrations of various kinds, and the attendance at these sessions is not reported, being counted as county agent work.

JUNIOR FARMERS' INSTITUTES.

For several years several counties have held special meetings for the boys, as separate sessions of the county institutes. These have generally been in connection with Boys' Corn Clubs, and in addition to a program furnished by the boys, the exhibition of the products grown by the members has been a prominent feature of the meeting.

During the past year, in cooperation with the Department of Boys' and Girls' Club Work, a special Junior Institute was held at Croswell. The institute was conducted by Mr. S. C. Robinson, of the institute lecture force, with the assistance of Mr. C. A. Spaulding, Assistant Leader of Boys' Club Work, and Miss Anna B. Cowles, Assistant Leader of Girls' Clubs. The local arrangements were in charge of Supt. Powers and Principal Raven of the Croswell schools, under the general direction of County Commissioner of Schools, W. J. Musselman.

Not only was there a large attendance of the older pupils from the Croswell and neighboring rural schools, but teachers and pupils were in attendance from Brown City, Carsonville and other points in the county.

In addition to addresses by the State Speakers mentioned, several pupils furnished a symposium upon "Legumes," and various topics were presented by several rural teachers. Separate sessions for the boys and girls were held on one afternoon, at which Mr. Spaulding and Miss Cowles discussed respectively, "Club Work for Boys" and "Sewing Club Work for Girls." Among the special features was a demonstration of the preparation of a hot school lunch, at noon of the first day. A demonstration of group games during the forenoon of the second day, and an exhibition of moving pictures, showing Boys' and Girls' Club Prize Winners visiting Washington, D. C.

As indicating the scope of the work, the following are the topics discussed by the conductor of the institute, Mr. Robinson: "Influence of Pure Seed upon Crop Production;" "Results with Legumes in Michigan;" "Essential Points in Judging Live Stock," and an evening address upon "Wealth from Waste." Among the other topics presented were, "Agriculture from the Rural Teacher's Standpoint;" "Community Work in the Rural School;" "High School Extension Work;" "Teaching Agriculture in the High School from the Farmers' Standpoint" and "Teaching Agriculture in the High School from the Standpoint of a Business Man."

The interest and attendance were maintained throughout the five sessions as will be seen by referring to the report of the attendance, which amounted to 2,150 for the five sessions, with 525 present at the closing session. Among the results of the institute has been a marked change in the feeling of the farmers towards the agricultural department in the high school, greater attention to Boys' and Girls' Clubs on the part of both pupils and parents, and better work in the classes in agriculture.

FARMERS' WEEK.

At the close of the regular institutes, the usual Farmers' Week exercises were given at the Agricultural College. Instead, however, of having seven or eight courses running through the entire week, Monday afternoon and Tuesday were given up largely to lectures and demonstra-

tions on Soils and Crops; Wednesday was Dairy Day; Thursday was for the most part devoted to Animal Husbandry and Friday to Horticulture, with a special Potato section. A course in Poultry Raising was carried on throughout the week by the members of the department assisted by Mr. W. H. Card, of Connecticut. There was also a course in Home Economics carried on through four days, with a special Women's Congress on two afternoons.

Among the speakers, in addition to those connected with the various departments of the College were, Professor A. R. Whitson, of the University of Wisconsin, who gave two lectures on "Soils;" Prof. M. L. Fisher, of Purdue University, who spoke on "Farm Crops;" Prof. J. G. Fuller, of the University of Wisconsin, on "Animal Husbandry;" Prof. S. A. Beach, of the Iowa Agricultural College, on "Horticulture;" Prof. Isabel Bevier, of the University of Illinois, on "Home Economics;" Dr. Dorothy Mandenhall, of the University of Wisconsin, on "Child Welfare."

The evening programs were furnished by Gilbert McClurg, who gave an illustrated lecture, with moving pictures, entitled, "To the Shining Mountains and the Sunset Sea;" Samuel H. Ranck, of Grand Rapids, on "Rural Traveling Libraries," and Chas. W. Farr, of Chicago, who spoke on "Farm Life and the Children." One of the features of the week was the address by Dr. R. M. Wenley, of the University of Michigan, on "The Human Element," which was in the regular course of the Liberal Arts Union.

On Thursday evening the program was furnished by the M. A. C Dramatic Club, which under the direction of Professor E. S. King, presented the play "Back to the Farm." This play was prepared and printed under the auspices of the Extension Department of the University of Minnesota which very kindly allowed its presentation without the usual royalty and other charges. The play brought out a crowd which filled the College Armory to overflowing, and every one was more than pleased both with the play itself and its presentation.

The music for the week was of the usual high order and was supplied by various college musical organizations, under the direction of Professor Abel and Miss Freyhofer. The College Band, Girls' Glee Club, Mens' Glee Club, and various soloists were on the program.

ACKNOWLEDGMENTS.

In addition to those mentioned as taking part in the exercises of Farmers' Week, most of whom gave their services without pay, the work of the institutes was materially aided by the cooperation of various State departments and associations. The State Highway Department and the State Live Stock Sanitary Commission furnished speakers for a large number of meetings for which addresses in their respective lines were requested. The State Normal Schools and the Michigan Milk Producers Association also aided in the same way.

Among the business organizations which assisted in carrying on the institutes were the American Portland Cement Association and the Kentucky Tobacco Product Company, both of which supplied one of their experts for nearly a month entirely free of charge. The lecturers in no way attempted to advertise the goods of the companies represented by them, but they merely pointed out methods of using them by which

the best results can be obtained. The work done by the representatives was unusually satisfactory.

CONCLUSION.

The past year has demonstrated more fully than ever before that there is a place for the Farmers' Institutes as a part of the extension work of the college. Not only do they reach a class of farmers who cannot be reached by other lines, but they are the ones who most need its help. The farmers feel a personal interest in the institutes, and at these meetings not only obtain knowledge which they need in their daily work, but they gather inspiration which makes them better farmers and better citizens.

Respectfully submitted,

L. R. TAFT,

Superintendent of Farmers' Institutes.

East Lansing, Mich., June 30, 1917.

OFFICERS OF COUNTY INSTITUTE SOCIETIES, 1917-18.

County.	President.	Address.	Secretary.	Address.
Alcona	J. H. McIntyre	Harrisville	Frank LaChapelle	Harrisville.
Alger				
Allegan	Irving Fox	Allegan, R. F. D.	Glen Overton	Allegan.
Alpena	James Briscelden	Leer	J. D. Mulvena	Leer.
Antrim	T. N. Chapin	Bellaire	Chas. Underhill	Bellaire.
Arenac	Albert Christy	Sterling, R. 1	G. W. Cassidy	Standish.
Baraga				
Barry	Wm. Grozinger	Woodland	R. G. Brumm	Nashville.
Bay	John Smith	Munger	Harry H. Horton	Munger.
Benzie	R. B. Reynolds	Bendon, R. R. D.	John A. VanDeman	Benzonia.
Berrien	Adolph Knott	Niles	E. J. Smalledge	Eau Claire.
Branch	Linas Taylor	Quincy	F. C. Demarest	Coldwater, R. 4.
Calhoun	A. Smith	Stanley	Ray Cook	Homer.
Charlevoix	Frank House	Boyne Falls	E. H. Clark	Ironton.
Cass	Fred B. Wells	Cassopolis	W. C. Southworth	Cassopolis.
Cheboygan	David E. Culver	Wolverine	Frank G. Scott	Wolverine.
Chippewa				
Clare	W. H. Kennedy	Clare, R. 5	T. U. Fuller	Farwell.
Clinton	H. C. Oven	Ovid	J. H. Hubbard	Ovid, R. 3.
Crawford	L. B. Merrill	Roscommon, R. 1	Chas. Corwin	Roscommon, R. 1.
Delta				
Dickinson				
Eaton	W. E. Hale	Eaton Rapids	V. G. Griffith	Charlotte.
Emmet	Frank Stock	Petoskey	John Gehman	Pelston.
Genesee	Watson Billings	Davison, R. 1	Harry D. Gage	Clio, R. 2.
Gladwin	U. G. Reynolds	Gladwin	C. D. Waite	Gladwin.
Gogebic				
Grand Traverse	J. H. Lyon	Williamsburg	E. O. Ladd	Old Mission.
Gratiot	Fred Bradford	Alma	Luther Carter	Ithaca.
Hillsdale	T. J. Miller	Hillsdale	Geo. B. Smith	Addison.
Houghton				
Huron	E. C. Hobart	Bad Axe	Jas. T. Todd	Bad Axe.
Ingham	Walter R. Carven	Mason	Almon M. Chapin	Eden.
Ionia	Chas. T. Lockwood	Portland	V. I. Tyler	Portland.
Iosco	Wm. Latter	Whittemore, R. 2	J. A. Campbell	Tawas City.
Iron				
Isabella	W. T. Bandeen	Mt. Pleasant, R. 4	P. P. Pope	Mt. Pleasant, R. 3.
Jackson	Wm. A. Reed	Hanover	Lewis E. St. John	Grass Lake, R. F. D.
Kalamazoo	W. H. Smith	Kalamazoo	Harold Brickman	Kalamazoo.
Kalkaska	Homer Kerns	Kalkaska	Paul Hayward	So. Boardman.
Kent				
Lake	Irwin Brockelbank	Chase	John A. Irvine	Chase.
Lapeer	Geo. H. Force	Attica	Geo. W. Messer	Almont.
Leelanau	Frank Weiler	Sutton's Bay, R. 1	Theo. Esch	Sutton's Bay, R. 1.
Lenawee	Peter R. Roberts	Sand Creek	B. H. Anderson	Sand Creek.
Livingston	W. O. Richards	Oak Grove	Roy M. Lannen	Howell.
Mackinac				
Macomb	Frank L. True	Armada	Will L. Lee	Mt. Clemens.
Manistee	Arlie L. Hopkins	Bear Lake	C. W. Glover	Bear Lake.
Marquette	John Wieland	Marquette	F. H. Vandenboom	Marquette.
Mason	O. G. Prettyman	Scottville, R. 3	C. A. Rinehart	Scottville.
Mecosta	E. A. Ladner	Big Rapids, R. 3	G. H. Robison	Big Rapids, R. 3.
Menominee				
Midland	Clifford Shoupe	Midland, R. 1	A. E. Lawrence	Coleman, R. 3.
Missaukee	Frank Cavanaugh	McBain	Edward DeYoung	McBain.
Monroe	R. G. Vivian	Monroe, R. 4	J. B. Winslow	Temperance, R. 2.
Montcalm	Ernest Snyder	Lakeview	A. F. Edgerly	Edmore.
Montmorency	Geo. Hilderbrant	Atlanta	Peter Harper	Atlanta.
Muskegon	S. D. McNitt	Ravenna	Thos. F. Rogers	Ravenna.
Newaygo	Will W. Carter	Grant	J. R. Wallace	Fremont.
Oakland	C. S. Bartlett	Pontiac		
Oceana	A. C. Kocher	Shelby	A. J. Adams	Shelby.
Ogemaw	Harry Grow	West Branch	Edw. E. Mathews	West Branch.
Ontonagon				
Osceola	Duane Briggs	Dighton	Cecil F. Snowden	Dighton.

OFFICERS OF COUNTY INSTITUTES—Concluded.

County.	President.	Address.	Secretary.	Address.
Oscoda	Chauncey Zook	Mio	M. S. Steiner	Fairview.
Otsego	A. Van Auken	Vanderbilt	Dorr D. Buell	Elmira.
Ottawa				
Presque Isle	J. M. Whitsitt	Millersburg	John Inglis	Millersburg.
Roscommon	Chas. R. Chase	Roscommon	Adolf Oleson	Roscommon.
Saginaw	Fred Cornair	Chesaning	Herbert Vasold	Freeland.
St. Clair	A. J. Smith	Capac	H. J. Vogt	Richmond.
St. Joseph	Verne Olney	Mendon	C. L. Harrison	Constantine.
Sanilac	W. A. Ellis	Marlette, R. F. D	Archie J. McLachlin	Argyle.
Shiawassee	O. J. Snyder	Owosso, R. 4	F. M. Crowe	Owosso.
Tuscola	W. F. Dowling	Fairgrove	Clarence Donahue	Colling.
Van Buren	Robert Anderson	Covert	Carl Buskirk	Paw Paw.
Washtenaw			G. W. Preston	Ypsilanti.
Wayne	Chas. Evans	Belleville	Milton Carmichael	Detroit.
Wexford	Frank Harris	Manton	John Harrison	Manton.

County Institutes with Dates and Attendance.

County.	Dates.	Place.	Attendance. First day. A.M.	First day. P.M.	First day. Eve.	Second day. A.M.	Second day. P.M.	Second day. Eve.	Women's Congress. A.M.	Women's Congress. P.M.	Total.	Average per session.
Alcona	Jan. 8–9	Harrisville	11	40	33	33	50			76	242	48
Alger												
Allegan	Feb. 9–10	Dorr	65	120		55	125			25	390	98
Alpena	Jan. 5–6	Long Rapids		35	65	20	40			37	197	49
Antrim	Jan. 15–16	Elk Rapids	67	95	119	63	110			132	586	117
Arenac	Jan. 12–13	Standish	50	100	65	40	60			48	363	73
Baraga												
Barry	Feb. 9–10	Hastings	40	125	20	100	188		30	95	578	116
Bay	Jan. 29	Munger	22	90	52						164	82
Benzie	Jan. 11–12	Benzonia	110	125	75	125	200			60	695	139
Berrien	Feb. 23–24	Eau Claire	200	300	125	145	225		43	72	1,110	222
Branch	Feb. 16–17	Coldwater	35	90	60	38	100			40	363	73
Calhoun	Feb. 7–8	Battle Creek	25	40		24	60				761	152
Cass	Feb. 14–15	Cassopolis	65	185		99	256	156			149	37
Charlevoix	Jan. 17–18	Deer Lake	54	82	60	26	30			31	283	57
Cheboygan	Dec. 11–12	Wolverine	23	55	95	75	100			28	376	75
Chippewa												
Clare	Jan. 25–26	Clare	20	50	116	33	65			72	356	71
Clinton	Jan. 22–23	Ovid	20	157	100	57	200			100	634	127
Crawford	Dec. 8–9	Grayling		30	42	32	50				154	39
Delta												
Dickinson												
Eaton	Jan. 17–18	Charlotte	100	200	90	150	250				790	158
Emmet	Dec. 13–14	Harbor Springs	29	75	145	29	60				338	68
Genesee	Feb. 5–6	Clio		110	95	80	185				470	118
Gladwin	Jan. 11–12	Gladwin	34	100	160	50	64	170		60	638	106
Grand Traverse	Jan. 10–11	Traverse City	25	49	105	170	220	218		42	1,066	152
	Jan. 12	Traverse City	237									
Gratiot	Jan. 23–24	Ithaca	67	188	66	76	261			105	782	156
Hillsdale	Feb. 19–20	Hillsdale	60	81	41	90	168				440	88
Houghton												
Huron	Jan. 31–Feb. 1	Harbor Beach	30	111	85	141	160	150		130	807	135
Ingham	Jan. 19–20	Mason	10	32	31	29	70			185	357	71
Ionia	Feb. 13–14	Portland	75	185	80	110	240			72	762	152
Iosco	Jan. 10–11	Whittemore	20	60	100	80	120			90	570	114

Iron												
Isabella	Jan. 24–25	Mt. Pleasant	62	160	66	76	180			50	594	119
Jackson	Feb. 20–21	Hanover	70	135	170	100	160		20	103	658	132
Kalamazoo	Feb. 21–22	Richland	23	64	100	53	125	147			512	119
Kalkaska	Jan. 8–9	Kalkaska		60	80	143	192	47		150	751	107
Kalkaska	Jan. 10	Kalkaska	41	38								
Kent												
Lake	Dec. 22–23	Chase	15	20	80	38	36			25	214	43
Lapeer	Feb. 2–3	Lapeer	50	125	22	100	130			50	477	95
Leelanau	Jan. 12–13	Sutton's Bay	73	140	200	72	177		50	95	807	161
Lenawee	Feb. 21–22	Adrian	100	350	300	300	250			375	2,375	339
Lenawee	Feb. 23	Adrian	200	400								
Livingston	Mar. 2–3	Howell	33	140	75	70	150		69	286	823	165
Mackinac												
Macomb	Feb. 27–28	Washington	27	63	119	54	78			80	421	84
Manistee	Jan. 17–18	Bear Lake		285	400	375	500	425		60	3,055	436
Manistee	Jan. 19	Bear Lake	410	600								
Marquette												
Mason	Jan. 19–20	Ludington	75	150	25	100	140			145	635	127
Mecosta	Feb. 15–16	Big Rapids	17	100	165	65	60			85	492	98
Menominee	Apr. 20	Spalding		125	53						178	89
Midland	Jan. 26–27	North Bradley	65	100	125	50	65			84	484	98
Missaukee	Dec. 20–21	McBain	63	120	118	130	150			22	603	121
Monroe	Feb. 23–24	Samaria	30	93	120	70	100			90	503	101
Montcalm	Feb. 14–15	Lakeview	150	450	220	165	375	350		250	1,960	352
Montmorency	Dec. 12–13	Atlanta		20	54					40	114	57
Muskegon	Feb. 5–6	Ravenna	15	55	43	25	40			39	217	43
Newaygo	Jan. 31–Feb. 1	Grant	58	102	75	150	160		50	100	695	139
Oakland	Feb. 28–Mar. 1	Pontiac	24	61	45	24	53		25	76	308	62
Oceana	Feb. 2–3	Shelby*	21	45	15	28	65				174	35
Ogemaw	Dec. 5–6	West Branch	25	125	153	63	150			48	564	113
Ontonagon												
Osceola	Feb. 16–17	Hersey	50	80	175	150	200			77	732	146
Oscoda	Nov 27	Fairview	40	85	125						250	83
Otsego	Dec. 15–16	Elmira	10	75	125	25	40			42	317	63
Ottawa												
Presque Isle	Jan. 3–4	Millersburg	50	125	125	50	100			125	575	115
Roscommon	Dec. 7–8	Roscommon	15	50	150	35	45			30	325	108
Saginaw	Jan. 30–31	Saginaw	15	100	75	75	100	75		128	693	87
Saginaw	Feb. 1	Saginaw	40	85								
St. Clair	Feb. 1–2	Port Huron	25	125	35	100	200				485	97
St. Joseph	Feb. 16–17	Leonidas	24	35	131	45	91			85	411	80
Sanilac	Jan. 30–31	Snover	43	200	281	80	190	294	54	160	1,302	217
Schoolcraft												

County Institutes with Dates and Attendance.—Concluded.

County.	Dates.	Place.	Attendance.								Total.	Average per session.
			First day.			Second day.			Women's Congress.			
			A.M.	P.M.	Eve.	A.M.	P.M.	Eve.	A.M.	P.M.		
Shiawassee	Feb. 21–22	Owosso	28	185	......	114	248	......	......	80	655	164
Tuscola	Jan. 29–30	Caro	50	163	40	125	200	......	......	108	686	137
Van Buren	Feb. 12–13	Bangor	70	147	125	163	285	......	23	39	862	172
Washtenaw	Feb. 22–23	Ann Arbor	35	60	50	50	125	......	22	52	320	64
Wayne	Feb. 26–27	Plymouth	40	152	119	84	160	......	......	......	629	126
Wexford	Dec. 18–19	Manton	20	54	66	25	47	......	......	19	231	46
Farmers' Week	Mar. 5–6	Agricultural College	......	250	400	400	600	800	......	500		
	Mar. 7–8		500	600	1,000	500	600	600	......	350	7,550	581
	Mar. 9		350	450	......	......	......	......	......	......		

*Bad storm.

Total attendance at County Institutes 48,821
Total number of sessions 347
Average attendance per session 141

One Day Institutes with Dates and Attendance.

County.	State speaker.	Place.	Dates.	County secretary.	Attendance. A. M.	Attendance. P. M.	Attendance. Eve.	Total.	Average per session.
Allegan	T. A. Farrand	Pullman	Dec. 12	C. L. Goodrich	30	45	85	160	53
		Dunningville	Dec. 13		10	90	......	100	50
		Cheshire	Dec. 14		......	60	......	60	60
	V. I. Safro	Leisure	Jan. 4		75	150	......	225	113
		Saugatuck	Jan. 6		42	80	......	122	61
	D. L. Hagerman	Graafschaap	Jan. 8		15	40	......	55	28
		Hamilton	Jan. 9		80	160	200	440	147
		Overisel	Jan. 10		100	135	......	235	118
	Jason Woodman	Trowbridge	Feb. 27		32	58	......	90	45
		Martin	Feb. 28		45	67	......	112	56
		Hopkins	Mar. 1		50	82	......	132	66
		Plainwell	Mar. 2		47	65	......	112	56
Antrim	R. D. Bailey	Mancelona	Dec. 13	Mrs. Jacob Winters	10	30	......	40	20
		Grass Lake (Grange Hall)	Dec. 13		45	47	30	122	41
		Bellaire	Dec. 15		12	38	60	110	37
		Eastport	Dec. 16		50	52	18	120	40
Arenac	S. C. Robinson	Sterling	Feb. 20	Geo. Cassidy	......	101	115	216	108
		Arenac	Feb. 21		12	100	203	315	105
Barry	F. N. Church	Woodland	Jan. 15	R. G. Brumm	37	335	300	672	224
		Carleton	Jan. 16		14	140	160	314	105
		Hickory Corners	Jan. 17		......	160	180	340	113
		Banfield	Jan. 18		25	150	120	295	98
		Assyria	Jan. 19		35	150	......	185	93
		Nashville	Jan. 20		35	268	......	303	152
		Glass Creek	Jan. 22		45	125	......	165	83
		Cressey	Jan. 23		36	120	140	296	99
		Middleville	Jan. 24		12	160	......	172	86
Bay	Newton Burns	Bentley	Jan. 9	Harry L. Horton	......	15	30	45	23
		Pinconning	Jan. 10		10	40	......	50	25
	S. C. Robinson	Auburn	Jan. 13		102	154	139	396	132

One Day Institutes.—Continued.

County.	State speaker.	Place.	Dates.	County secretary.	Attendance. A. M.	Attendance. P. M.	Attendance. Eve.	Total.	Average per session.
Benzie	L. R. Taft	Frankfort	Mar. 22	Jno. A. VanDeman	125	150	200	475	158
	R. H. Elsworth	Beulah	Mar. 23		55	65	....	120	60
Berrien		Galien	Jan. 17	Adolph Knott	60	86	....	146	73
		Three Oaks	Jan. 17		....	....	137	137	137
	Jason Woodman	Berrien Springs	Jan. 18		56	115	....	171	86
		Buchanan	Jan. 19		70	135	....	205	103
		Berrien Center	Jan. 20		36	124	....	160	80
		Watervliet	Jan. 23		50	106	35	191	64
	T. A. Farrand	Millburg	Jan. 24		151	253	301	705	235
	V. I. Safro	Sodus	Jan. 25		43	97	55	195	65
		Baroda	Jan. 26		50	166	....	216	108
	V. I. Safro	Stevensville	Jan. 27		50	161	....	211	106
	J. W. Henceroth	Bridgman	Feb. 26		53	100	....	153	77
Branch		California	Jan. 4	F. C. Demarest	56	135	179	370	123
	Geo. B. Smith	Kinderhook	Jan. 5		50	135	140	325	108
		Ovid Township	Jan. 6		35	50	58	108	54
		Quincy	Jan. 15		35	65	73	173	58
	L. W. Oviatt	Girard	Jan. 16		40	85	75	200	67
		Algansee	Jan. 17		50	60	73	183	61
		Bronson	Jan. 18		20	75	50	145	48
Calhoun	O. G. Barrett	Rice Creek	Jan. 22	Ray Cook	....	27	59	86	43
		Convis	Jan. 23		80	150	....	230	115
		Stanley	Jan. 24		37	107	128	272	91
		Abscota	Jan. 25		....	79	....	79	79
		Homer	Jan. 26		28	80	138	246	82
		Homer	Jan. 27		43	64	....	107	54
Cass	O. G. Barrett	Marcellus	Jan. 8	Alfred J. George	21	39	....	60	30
		Marcellus	Jan. 9		29	53	....	82	41
		La Grange	Jan. 10		35	59	....	94	47
		Jones	Jan. 11		63	210	55	328	109
		Penn	Jan. 12		10	20	....	30	15
		Union	Jan. 13		43	60	51	154	51
	Jason Woodman C. H. Hayes	Dailey	Jan. 26		45	63	....	108	54

Charlevoix	R. D. Bailey	Barnard	Jan. 2	H. L. Barnum	50	100	81	231	77
		Horton's Bay	Jan. 3		51	94	....	145	73
		Clarion	Jan. 4		34	65	62	161	54
		Boyne City	Jan. 5		....	42	37	79	40
		Boyne Falls	Jan. 6		37	70	51	158	53
		South Arm Gr. Hall	Jan. 8		....	38	....	38	38
Clare	N. A. Clapp	Farwell	Jan. 9	A. J. Archbold	100	200	250	550	183
		Harrison	Jan. 10		36	99	78	213	71
Dickinson	E. G. Amos	Sagola	Apr. 19	....	....	....	20	20	20
		Waucedah	Apr. 20		....	....	47	47	47
		Iron Mountain	Apr. 21		....	....	7	7	7
Eaton	F. N. Church Anna B. Cowles	Mulliken	Feb. 2	H. D. Burroughs L. Manager	....	55	60	115	58
	H. H. Musselman Mrs. C. L. Barber	Dimondale	Feb. 27	Ed. Vanderbeck	200	225	....	425	213
Emmet	R. D. Bailey	Bear Creek	Dec. 6	Geo. E. S. Cook	29	40	....	69	35
		Epsilon	Dec. 7		35	76	....	111	56
		Brutus	Dec. 8		....	29	....	29	29
		Levering	Dec. 9		....	27	24	51	26
		East Bliss	Dec. 11		33	44	....	77	39
		Goodhart	Dec. 12		37	45	....	82	41
Genesee	C. W. Melick	Atlas	Jan. 9	J. Guy Blackington	44	107	125	276	92
		Otisville	Jan. 10		....	177	150	327	164
		Genesee	Jan. 11		36	85	75	196	65
		Montrose	Jan. 12		....	140	40	180	90
		Flushing	Jan. 13		24	150	110	284	95
	W. F. Taylor	Grand Blanc	Jan. 29		65	210	200	475	158
		Goodrich	Jan. 30		175	250	270	695	232
		Davison	Jan. 31		60	230	210	500	167
		Swartz Creek	Feb. 2		*35	129	75	239	80
		Gaines	Feb. 3		*6	75	....	81	41
Gladwin	W. F. Taylor	Wagerville	Dec. 5	C. D. Waite	....	43	98	141	71
		Sherman	Dec. 6		....	40	94	134	67
		Smith Creek	Dec. 7		25	38	86	149	50
		Grout	Dec. 8		23	36	60	119	40
		Dale	Dec. 9		....	114	94	208	104

One Day Institutes.—Continued.

County.	State speaker.	Place.	Dates.	County secretary.	Attendance. A. M.	Attendance. P. M.	Attendance. Eve.	Total.	Average per session.
Grand Traverse	F. L. Dean	Grant Center	Jan. 4	E. O. Ladd	150	200	....	350	175
		Kingsley	Jan. 5		200	250	....	450	225
		Williamsburg	Jan. 6		12	25	....	37	19
Gratiot	C. W. Melick	Middleton	Jan. 16	Luther Carter	10	95	75	180	60
		Pompeii	Jan. 17		65	115	50	230	77
		Ashley	Jan. 18		80	141	95	316	105
	L. W. Oviatt	St. Louis	Jan. 19	Dr. A. W. Wheeler, Local Manager	95	225	200	520	173
	C. W. Melick	St. Louis	Jan. 20		150	350	....	500	225
	C. W. Melick	Sickles	Jan. 21	Luther Carter	65	203	200	468	156
Hillsdale	Geo. B. Smith	Litchfield	Jan. 22	A. Z. Nichols	....	150	275	425	213
		Allen	Jan. 23		175	400	500	1,075	358
		North Adams	Jan. 24		50	138	150	338	113
		Montgomery	Jan. 25		40	125	150	315	105
		Pittsford	Jan. 26		10	100	113	223	78
Huron	S. C. Robinson	Grant Township	Jan. 16	Jas. T. Todd	30	70	....	100	50
		Bad Axe	Jan. 17		85	420	490	995	332
		Port Hope	Jan. 18		....	75	200	275	138
		Ubly	Jan. 19		....	150	230	380	190
		Kinde	Jan. 20		60	250	300	610	203
		Verona	Jan. 22		35	75	180	290	97
		Pigeon	Jan. 23		12	140	145	297	99
		Sebewaing	Jan. 24		150	213	157	520	173
		Sebewaing	Jan. 25		100	175	....	275	138
Ingham	E. M. Moore	Locke	Jan. 8	W. H. Freshour	....	35	....	35	35
		Holt	Jan. 9		15	75	125	215	72
		Aurelius	Jan. 10		....	45	....	45	45
		Leslie	Jan. 11		....	40	....	40	40
		Dansville	Jan. 12		....	160	100	260	130
		Dansville	Jan. 13		150	300	....	450	225
		Stockbridge	Jan. 15		....	100	100	200	100

Ionia	S. C. Robinson	Danby	Feb. 5	Veryl Tyler	18	85	....	103	52
		Clarksville	Feb. 6		....	209	175	384	192
		South Boston	Feb. 7		48	180	....	228	114
		Orleans	Feb. 9		98	140	....	238	119
		Orange	Feb. 10		135	189	160	484	161
	V. M. Shoesmith	Lake Odessa	Feb. 21	W. Z. Carter, Local Manager	300	350	....	650	325
	F. L. Dean E. C. Martindale Dr. R. P. Lyman	Ionia	Feb. 23	S. F. Gates, Local Manager	40	155	100	295	148
		Ionia	Feb. 24		50	145	....	195	98
Iosco	S. C. Robinson	Hale	Dec. 5	J. A. Campbell	16	80	70	166	55
		Sherman Twp	Dec. 6		25	50	70	145	48
		Grant	Dec. 7		50	80	150	280	93
		Alabaster	Dec. 8		95	110	....	205	103
Isabella	S. C. Robinson	Blanchard	Dec. 13	P. P. Pope	10	150	320	480	160
		Blanchard	Dec. 14		15	150	30	195	65
		Brinton	Dec. 16		30	35	....	65	33
	C. W. Melick	Shepherd	Feb. 2		100	250	150	500	250
		Shepherd	Feb. 3		100	300	....	400	200
Jackson	Geo. B. Smith	Concord	Feb. 5	W. W. McLain	35	200	150	385	128
		Parma	Feb. 6		65	275	175	515	172
		Devereaux	Feb. 7		55	135	175	365	132
		Tompkins	Feb. 8		25	160	110	285	95
		Rives	Feb. 9		90	215	125	430	143
	W. F. Taylor	Layton's Corners	Feb. 10		50	150	....	200	100
		West Liberty	Feb. 12		45	140	75	260	87
		Brooklyn	Feb. 13		12	40	65	117	39
		Napoleon	Feb. 14		90	180	180	450	150
		Michigan Center	Feb. 15		40	85	....	125	63
		Grass Lake	Feb. 16		25	75	48	148	49
		Waterloo	Feb. 17		50	130	115	295	98
Kalamazoo	A. Bentall	Texas	Dec. 5	Harold Buckham	45	65	....	110	55
		Oshtemo	Dec. 6		43	96	74	213	71
		Galesburg	Dec. 7		30	42	34	96	32
		Galesburg	Dec. 8		48	38	....	106	53
	T. A. Farrand	Damon Church	Dec. 19		35	45	35	115	38
		Augusta	Dec. 20		20	40	....	60	30
		Jickling School	Dec. 21		50	75	40	165	55
		W. Oshtemo	Dec. 22		50	80	....	130	65

One Day Institutes.—Continued.

County.	State speaker.	Place.	Dates.	County secretary.	Attendance. A. M.	Attendance. P. M.	Attendance. Eve.	Total.	Average per session.
Kalamazoo—Concluded..	H. J. Lurkins	Fulton	Jan. 2..	Harold Buckham....	20	48	70	138	46
		Kalamazoo	Jan. 3..		35	45	....	80	40
		Alamo	Jan. 4..		55	85	....	140	70
		Ross Township	Jan. 5..		20	48	....	68	34
	C. H. Bramble	Climax	Jan. 10..		27	57	67	151	50
		Schoolcraft	Jan. 11..		43	121	103	267	89
		Vicksburg	Jan. 12..		31	61	....	92	46
		Comstock	Jan. 13..		....	21	30	51	26
	Dr. C. H. Hays Ezra Levin	Portage	Jan. 16..		29	86	71	186	62
Kalkaska........	R. D. Bailey	Rapid City	Nov. 13..	Floyd E. Jenkins....	15	50	103	168	56
		Excelsior	Nov. 14..		15	35	60	110	37
		Spencer	Nov. 16..		65	75	....	140	70
		Valentine Gr. Hall	Nov. 17..		29	75	....	104	52
Lake............	R. D. Bailey	Bristol	Dec. 19..	C. A. Steger........	31	50	37	118	39
		Luther	Dec. 20..		....	11	12	23	12
		Sauble	Dec. 21..		....	29	23	52	26
Lapeer........	W. F. Taylor	North Branch	Jan. 13..	G. W. Messer.......	....	150	230	380	190
		Clifford	Jan. 15..		....	150	300	450	225
		Clifford	Jan. 16..		30	300	....	330	165
		Almont	Jan. 17..		30	185	210	425	213
		Almont	Jan. 18..		36	200	....	236	118
	W. F. Taylor	Hadley	Jan. 19..		....	125	510	635	318
	Mrs. C. L. Barber	Hadley	Jan. 20..		100	275	....	375	188
Leelanau........	Fred L. Dean	Empire	Jan 18....	Orson R. McClary....	....	90	125	215	108
Lenawee......	Geo. B. Smith	Hudson Center	Jan. 8..	Fred E. Morse......	50	100	100	250	83
		Rome	Jan. 9..		75	125	175	375	125
		W. Adrian	Jan. 10..		100	150	150	400	133
		Fruit Ridge	Jan. 11..		125	225	175	525	175
		Riga	Jan. 12..		....	100	60	160	80
		Cadmus	Jan. 13..		50	175	200	425	142

Lenawee.—*Con.*	O. G. Barrett	Rollin	Jan. 15	Fred E. Morse	*	77	....	74	76
		Onsted	Jan. 16		75	187	210	472	157
		Tipton	Jan. 17		96	143	119	358	119
		Tecumseh	Jan. 18		23	117	76	206	69
		Macon	Jan. 19		....	79	183	262	131
		Holloway	Jan. 20		72	119	....	191	96
	Chas. B. Cook	Medina	Jan. 22		....	74	103	177	89
		Lime Creek	Jan. 23		67	109	140	316	105
		Morenci	Jan. 24		250	500	600	1,350	450
		Ridgeville	Jan. 25		150	200	250	600	200
		Ogden Center	Jan. 26		125	325	500	950	317
		Madison	Jan. 27		75	175	150	400	134
Livingston	S. C. Robinson	Cohoctah	Feb. 12	Roy M. Lannen	....	160	....	160	160
		Hamburg	Feb. 13		....	48	53	101	51
		Brighton	Feb. 14		....	40	....	40	40
		Fowlerville	Feb. 15		160	290	....	450	225
		Pinckney	Feb. 16		....	....	....	....	....
		Gregory	Feb. 17		85	175	228	488	163
		Deerfield Center	Feb. 19		77	129	....	206	103
Macomb	W. F. Taylor	Richmond	Jan. 22	W. L. Lee	....	325	340	665	333
		Armada	Jan. 23		30	200	175	405	135
		Meade	Jan. 24		80	185	150	415	138
		Davis	Jan. 25		75	140	150	365	122
		Utica	Jan. 26		100	160	70	330	110
		Warren	Jan. 27		30	150	110	290	97
Manistee	F. L. Dean	Kaleva	Jan. 16	E. Billman	100	310	150	560	187
		Manistee	Feb. 16		....	....	200	200	200
Marquette	R. G. Carr	Sands	Dec. 11	F. M. Vandenboom	....	20	35	55	28
		Skandia	Dec. 12		....	....	20	20	20
		Green Garden	Dec. 13		....	....	11	11	11
		Chocolay	Dec. 14		....	....	....	....	....
		Marquette	Dec. 15		....	5	13	18	9
Mason	V. I. Safro	Harmony Gr. Hall	Dec. 18	C. A. Rinehart	8	12	....	20	10
		Freesoil	Dec. 19		10	46	....	56	28
		Summit	Dec. 20		10	30	....	40	20
		Riverton	Dec. 21		....	4	....	4	4

One Day Institutes.—Continued.

County.	State speaker.	Place.	Dates.	County secretary.	Attendance. A. M.	Attendance. P. M.	Attendance. Eve.	Total.	Average per session.
Mecosta	F. L. Dean	Millbrook	Jan. 24	G. H. Robison	12	75	90	177	59
		Remus	Jan. 25		25	150	125	300	100
		Barryton	Jan. 26		25	110	....	135	68
Menominee	C. V. Ballard	Faithorn	Nov. 8	....	....	15	85	100	50
		Nadeau	Nov. 13		....	23	5	28	14
		Stephenson	Nov. 14		....	12	10	22	11
		Greenwood	Nov. 15		....	21	....	21	21
	R. G. Carr	Wallace	Apr. 16	E. B. Hill	....	40	38	78	39
		Stephenson	Apr. 17		....	125	56	181	91
		Daggett	Apr. 18		....	137	103	240	120
		Carney	Apr. 19		....	113	92	205	103
Midland	S. C. Robinson	Laporte	Jan. 3	A. E. Lawrence	25	125	140	290	97
		Smith's Crossing	Jan. 4		25	31	90	146	49
		Poseyville	Jan. 5		10	70	160	240	80
		Geneva	Jan. 6		35	60	110	205	68
		Homer	Jan. 8		40	100	150	290	97
		Midland	Jan. 9		45	60	25	130	43
		Hope	Jan 10		18	120	210	348	116
		Averill	Jan. 11		30	100	200	330	110
		Coleman	Jan. 12		60	200	250	510	170
Missaukee	S. C. Robinson	Moorestown	Dec. 22	Edward DeYoung	....	55	71	126	63
		Lake City	Dec. 23		48	60	13	121	40
	C. H. Gaskill	Shippy	Jan. 15		....	32	65	97	49
Monroe	O. G. Barrett	Temperance	Feb. 1	J. B. Winslow	43	95	....	138	69
		Dundee	Feb. 2		100	275	....	375	188
		Petersburg	Feb. 3		207	350	....	557	279
		Maybee	Feb. 5		....	175	225	400	200
		Carleton	Feb. 6		60	87	110	257	86

Monroe—*Con.*	Mrs. C. L. Barber; N. A. Clapp	Carleton	Feb. 7	J. B. Winslow	78	197	....	275	138
	O. G. Barrett	Monroe	Feb. 7		40	90	34	164	55
		Raisinville	Feb. 8		64	110	....	174	87
	W. F. Taylor; L. W. Oviatt; Mrs. Stockman	Milan	Feb. 26		43	190	225	458	153
		Milan	Feb. 27		225	425	....	650	325
Montcalm	F. N. Church	Greenville	Feb. 3	H. Mulholland	40	100	....	140	70
		Coral	Feb. 5		35	180	155	370	123
		Howard City	Feb. 6		40	200	150	390	130
		Six Lakes	Feb. 7		210	240	190	640	213
		Vestaburg	Feb. 8		60	220	230	610	203
		Stanton	Feb. 9		190	315	180	685	228
		Carson City	Feb. 10		50	140	37	227	76
		Sheridan	Feb. 12		75	150	135	360	120
Montmorency	C. H. Gaskill	Lewiston	Dec. 11	C. A. Rice	10	50	57	117	39
		Big Rock	Dec. 12		....	50	55	105	53
	David Woodman	Royston	Jan. 18		11	28	63	102	34
Muskegon	F. L. Dean	Dalton	Jan. 29	R. Leslie Olds	15	30	25	70	23
		Cloverville	Jan. 30		35	75	100	210	70
		Lake Harbor	Jan. 31		75	150	125	350	117
Newaygo	F. N. Church	Bitely	Jan. 8	J. R. Wallace	30	45	....	75	38
		Troy	Jan. 9		45	85	....	130	65
		White Cloud	Jan. 10		40	85	....	125	63
		Sitka	Jan. 11		28	81	....	109	55
		Dayton Center	Jan. 12		29	78	....	107	54
	W. P. Hartman	Hawkins	Mar. 14		....	200	150	350	175
Oakland	R. D. Bailey	Ortonville	Feb. 10	Howard A. Green	48	256	96	400	133
		Waterford	Feb. 12		11	94	115	220	73
		Highland	Feb. 15		46	83	....	129	65
	W. F. Taylor	Wixom	Feb. 19		30	113	....	143	72
*Oceana	E. M. Moore; V. I. Safro	Benona	Dec. 11	A. J. Adams	....	52	....	52	52
		Cranston	Dec. 12		40	100	....	140	70
		New Era	Dec. 13		....	20	35	55	28
		Blooming Valley	Dec. 14		14	40	....	54	27
		Mears	Dec. 15		40	50	....	90	45

One Day Institutes.—Continued.

County.	State speaker.	Place.	Dates.	County secretary.	Attendance. A. M.	Attendance. P. M.	Attendance. Eve.	Total.	Average per session.
Ontonagon	L. R. Walker	Trout Creek	Jan. 8	R. G. Carr, County Agent	56	5	12	73	24
		Paynesville	Jan. 9		....	75	27	102	51
		Bruce Crossing	Jan. 10		27	30	....	57	29
		Ontonagon	Jan. 11		180	30	13	223	74
		Rockland	Jan. 12		....	40	41	81	41
	E. B. Hill	Mianola	Apr. 30		....	75	....	75	75
		Mass City	Apr. 30		....	....	45	45	45
		Green	May 1		26	....	....	26	26
		Ontonagon	May 1		....	250	....	250	250
		Paynesville	May 2		....	53	....	53	53
		Ewen	May 2		....	....	65	65	65
		Maple Grove	May 3		....	33	....	33	33
		Bruce Crossing	May 3		....	....	53	53	53
		Topaz	May 4		....	20	....	20	20
		Trout Creek	May 4		....	....	43	43	43
Osceola	E. M. Moore	Evart	Dec. 4	John Vance	18	55	225	298	99
		Marion	Dec. 5		15	130	160	305	102
		Dighton	Dec. 6		54	175	350	579	193
		Tustin	Dec. 7		25	75	....	100	50
		LeRoy	Dec. 8		60	105	130	295	98
		Reed City	Dec. 9		20	50	....	70	35
Oscoda	R. D. Bailey	Comins	Nov. 25	M. S. Steiner	....	30	80	110	55
Otsego	F. L. Dean Mrs. E. J. Creyts	Gaylord	Dec. 9	D. D. Buell	15	50	18	83	28
Ottawa	A. Bentall	Jamestown	Jan. 17	H. L. Hagerman, County Agent	44	89	....	133	67
		Hudsonville	Jan. 18		65	85	....	150	75
		Forest Grove	Jan. 30		85	125	....	210	106
		Holland	Jan. 31		385	485	....	870	435

Presque Isle	L. W. Oviatt	Onaway	Mar. 13	Geo. A. Morris, Local Manager	25	28	150	203	68
	Mrs. Dora Stockman	Onaway	Mar. 14		34	65	125	222	74
		Onaway	Mar. 15		107	175	....	282	141
	C. H. Knopf	Onaway	Mar. 16		110	110	....	220	110
	C. H. Knopf	Hagensville	Mar. 22		30	45	70	145	48
Saginaw	W. F. Taylor	Bridgeport	Feb. 5	J. D. Proper	15	45	....	60	30
		Hemlock	Feb. 6		30	200	....	230	115
		Frankenmuth	Feb. 7		75	250	....	325	163
		Chesaning	Feb. 8		60	150	....	210	105
		Grant	Feb. 9		....	75	40	115	58
		Brady	Feb. 10		....	80	....	80	80
St. Joseph	E. C. Martindale	Moorepark	Jan. 8	C. L. Harrison	46	112	150	308	103
		Riverside	Jan. 9		45	83	96	224	75
		Constantine	Jan. 10		70	250	300	570	190
		Mottville	Jan. 11		30	60	40	130	43
		Klinger Lake	Jan. 12		55	85	70	210	70
		White Pigeon	Jan. 13		30	190	....	220	110
	Jason Woodman	Burr Oak	Feb. 13		21	53	....	74	37
		Parkville	Feb. 14		40	40	....	80	40
Sanilac	W. F. Taylor	Marlette	Jan. 2	Archie McLachlin	108	230	170	508	169
		Shabbona	Jan. 3		....	70	295	365	183
		Argyle	Jan. 4		19	196	360	575	192
		Sandusky	Jan. 5		....	40	50	90	45
		Carsonville	Jan. 6		....	130	170	300	150
		Croswell	Jan. 8		20	168	85	273	91
		Lexington	Jan. 9		....	75	202	277	139
		Brown City	Jan. 11		47	300	250	597	199
		Brown City	Jan. 12		90	390	....	480	240
	S. C. Robinson	Croswell (a)	Feb. 23	Supt. G. E. Powers, Local Manager	325	500	400	1,225	308
		Croswell (a)	Feb. 24		400	525	....	925	463
Schoolcraft	W. F. Raven	Germfask	Dec. 11	E. G. Amos, County Agent	....	....	50	50	50
		Doyle	Dec. 12		....	....	26	26	26
		Buell Gr. Hall	Dec. 13		....	25	50	75	38
		Tompson	Dec. 14		....	45	15	60	30
		Hutchins Gr. Hall	Dec. 15		....	20	35	55	28
		Hiawatha	Dec. 16		....	....	20	20	20
	E. G. Amos	Birthday Gr. Hall	Apr. 16		....	....	26	26	26
		Hutchins Gr. Hall	Apr. 17		....	....	6	6	6

(a) Young Peoples' Institute.

One Day Institutes.—Concluded.

County.	State speaker.	Place.	Dates.	County secretary.	Attendance. A. M.	Attendance. P. M.	Attendance. Eve.	Total.	Average per session.
		Henderson	Feb. 7		40	60	75	175	58
Shiawassee	L. W. Oviatt	New Haven	Feb. 8	E. P. Sherman	40	125	....	165	83
		Perry	Feb. 9		20	100	60	180	60
		Maple River Ch.	Feb. 10		45	65	....	110	55
		Unionville	Feb. 1		21	165	230	416	139
		Akron	Feb. 2		175	290	108	573	191
		*Reese	Feb. 3		....	68	....	68	68
Tuscola	R. D. Bailey	Vassar	Feb. 5	Clarence Donahue	10	66	....	76	38
		Fostoria	Feb. 6		63	304	393	780	260
		Mayville	Feb. 7		33	425	172	630	210
		Kingston	Feb. 8		....	275	125	400	200
		Cass City	Feb. 9		....	188	....	188	188
		Kendall	Jan. 2		13	75	....	88	44
	Jason Woodman	Gobleville	Jan. 3		....	89	....	89	89
		Bloomingdale	Jan. 4		....	59	....	59	59
		Kibbie	Jan. 5		33	65	....	98	49
		Keeler	Jan. 9		....	94	....	94	94
Van Buren	H. J. Lurkins	Glendale	Jan. 10	Robt. Anderson	18	43	....	61	30
		Grand Junction	Jan. 11		24	60	....	84	42
		Covert	Jan. 12		44	100	....	144	72
		Almena	Feb. 5		....	50	....	50	50
	A. Bentall	Decatur	Feb. 6		35	125	50	210	70
		Lawrence	Feb. 7		55	125	....	180	90
		Salem	Feb. 5		55	236	110	401	134
		Cherry Hill	Feb. 6		65	178	285	528	176
		Ypsilanti	Feb. 7		43	118	....	161	81
		Northfield	Feb. 8		....	105	70	175	88
Washtenaw	E. M. Moore	North Lake	Feb. 9	G. W. Preston	....	60	150	210	105
		Chelsea	Feb. 10		48	155	128	331	110
		Willis	Feb. 12		....	285	223	508	254
		Saline	Feb. 13		55	252	148	455	152
		Manchester	Feb. 15		23	300	255	578	193

Wayne	O. G. Barrett	Northville	Feb. 9	E. R. Laing	47	81	200	328	109
		Canton	Feb. 10		19	85	110	214	71
		Eureka	Feb. 12		16	84	112	212	71
		Belleville	Feb. 13		25	93	300	418	139
		Romulus	Feb. 14		30	110	264	404	135
		W. Sumpter	Feb. 15		46	125	200	371	124
		Willow	Feb. 16		25	106	200	331	110
		Flat Rock	Feb. 17		104	257	300	661	220
		Inkster	Feb. 19		25	120	74	219	73
		Redford	Feb. 20		45	192	....	237	119
Wexford	F. L. Dean	Harlan	Dec. 20	J. F. Zimmer, County Agent	50	155	....	205	103
		Cadillac	Dec. 21		50	140	....	190	95
		Meawautaka	Dec. 22		76	105	....	181	91

Women's Congresses at One-Day Institutes.

County.	Speaker.	Place.	Dates.	Chairman.	Attendance.		Total.	Average.
					A. M.	P. M.		
Calhoun	Miss Mary Edmonds	Homer	Jan. 27	....	....	80	80	80
Gratiot	Mrs. Helen A. Hill	St. Louis	Jan. 20	....	....	78	78	78
Ionla	Mrs. C. L. Barber	Ionia	Feb. 23	....	....	53	53	53
Monroe	Mrs. C. L. Barber	Carlton	Feb. 6	....	....	154	154	154
		Monroe	Feb. 7	....	....	48	48	48
Presque Isle	Mrs. Dora Stockman	Onaway	Mar. 13	....	....	65	225	75
		Onaway	Mar. 14	....	....	75		
		Onaway	Mar. 15	....	....	85		

Total number of One-day Institutes	403
Total number of sessions	934
Total attendance One-day Institutes	97,535
Average attendance per session	104
Total attendance, Women's Congresses, One-day Institutes	638
Grand total attendance	146,994

REPORT OF THE DEAN OF ENGINEERING.

Dr. F. S. Kedzie, President, Michigan Agricultural College.

Dear Sir—This communication is my tenth annual report as Dean of Engineering.

NEW BUILDINGS.

The fiscal year just closed has been marked by the construction of the new engineering buildings to replace those destroyed by fire on March 5, 1916, as recounted in my last report.

Owing to general labor conditions the buildings were not finished until many months after the contract time but arrangements were made for partial occupancy and by the opening of the spring term practically all of the engineering work of the division was cared for in the new quarters.

Appended to this report are plans of the several buildings, as per following:

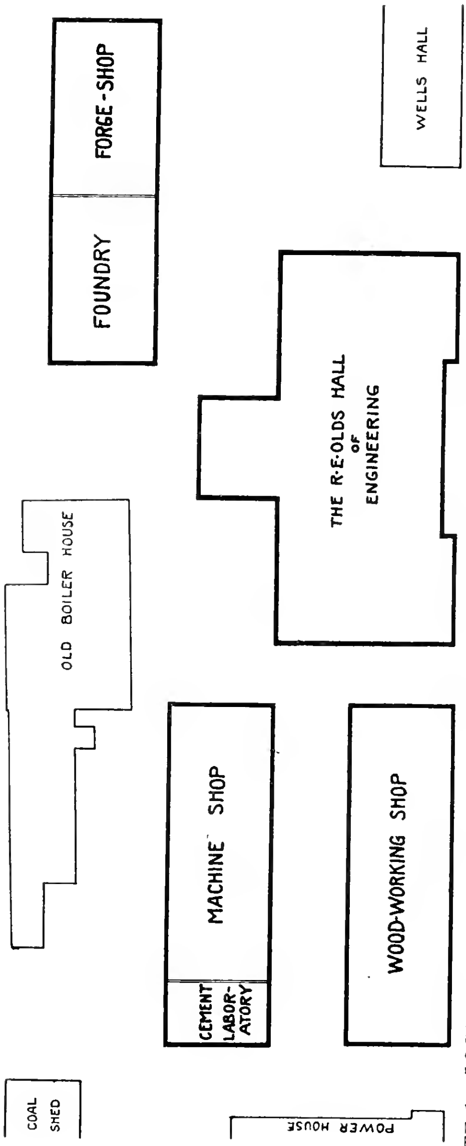


PLATE 1.—LOCATION OF THE NEW ENGINEERING BUILDINGS IN RELATION TO OTHER COLLEGE BUILDINGS.

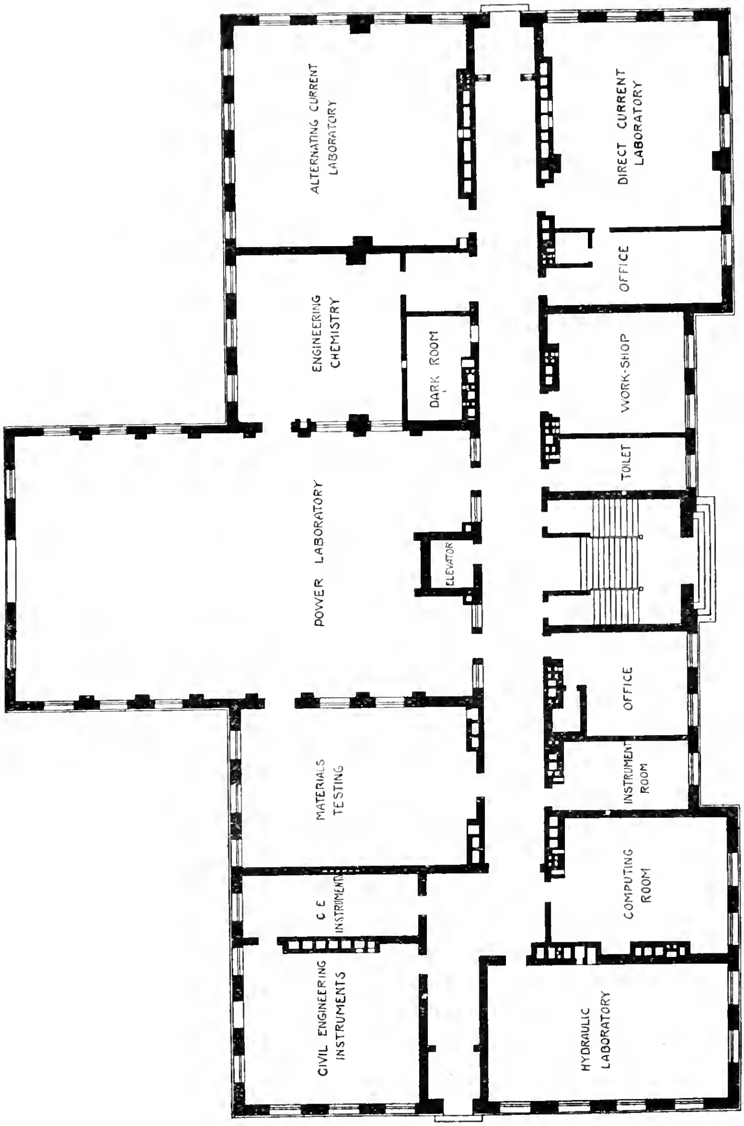


PLATE 2.—GROUND FLOOR PLAN OF THE R. E. OLDS HALL OF ENGINEERING.

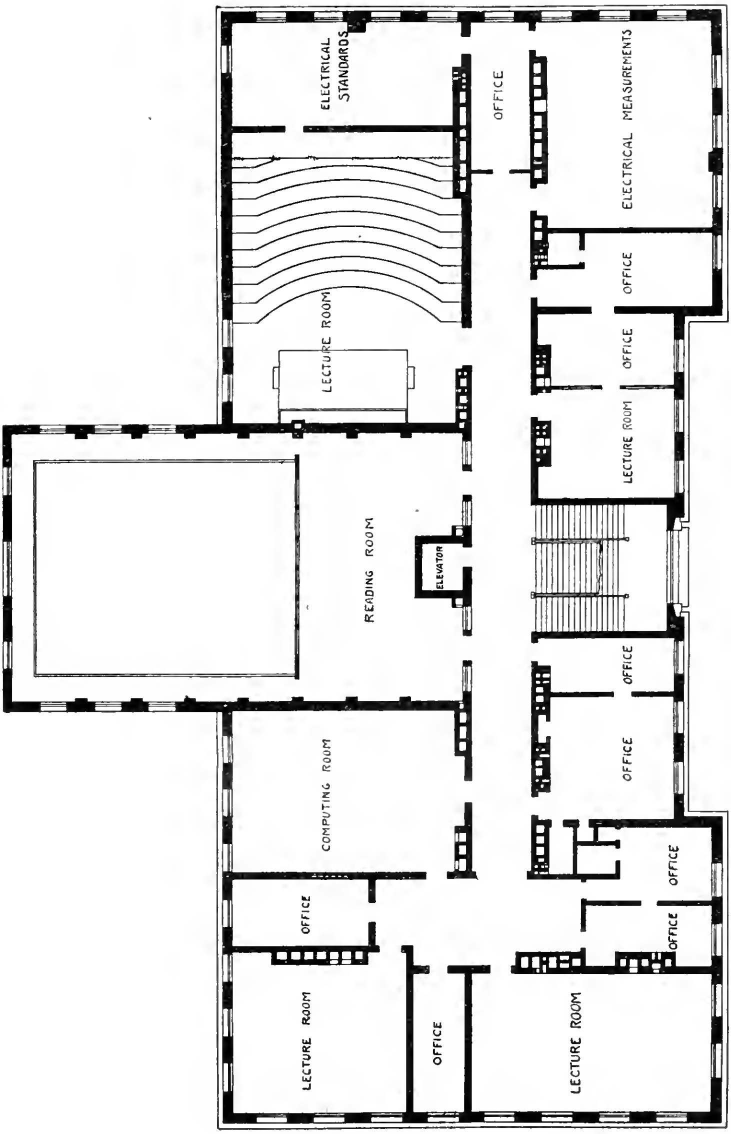


PLATE 3.—FIRST FLOOR PLAN OF THE R. E. OLDS HALL OF ENGINEERING.

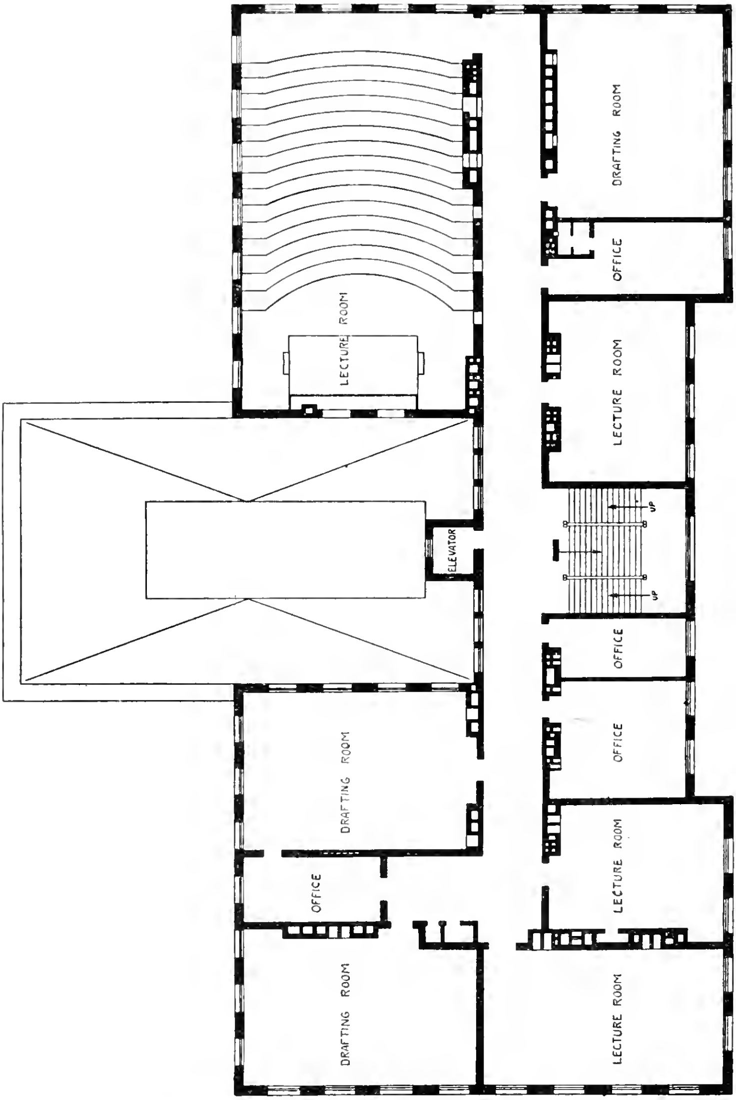


PLATE 4.—SECOND FLOOR PLAN OF THE R. E. OLDS HALL OF ENGINEERING.

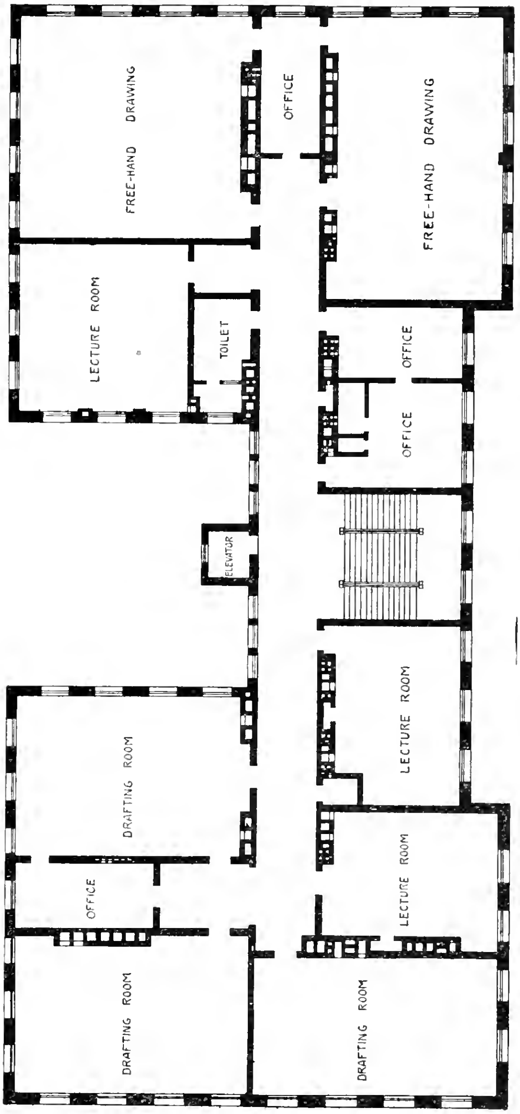


PLATE 5.—THIRD FLOOR PLAN OF THE R. E. OLDS HALL OF ENGINEERING.

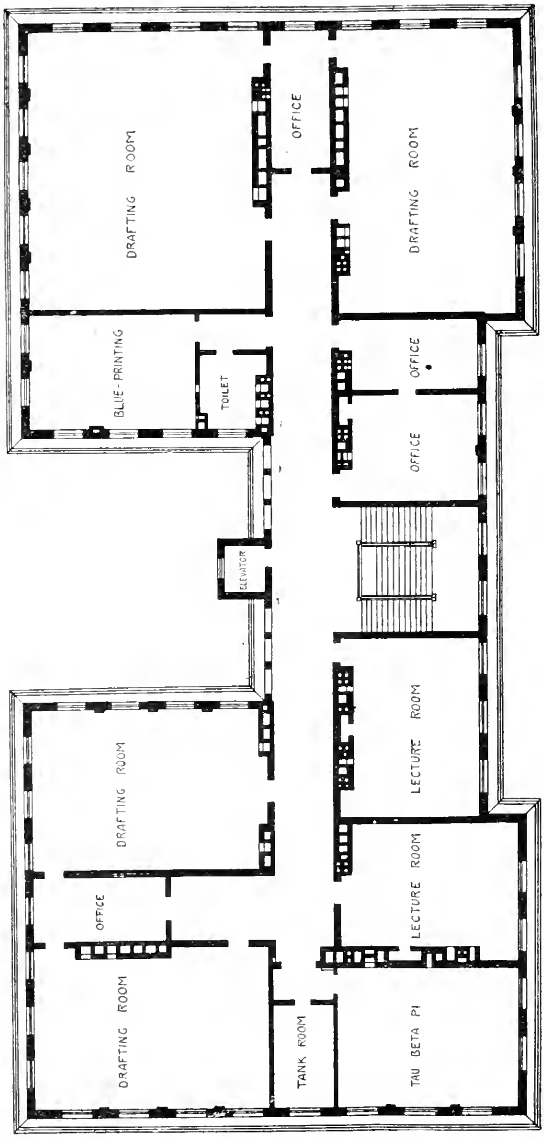


PLATE 6.—FOURTH FLOOR PLAN OF THE R. E. OLDS HALL OF ENGINEERING.

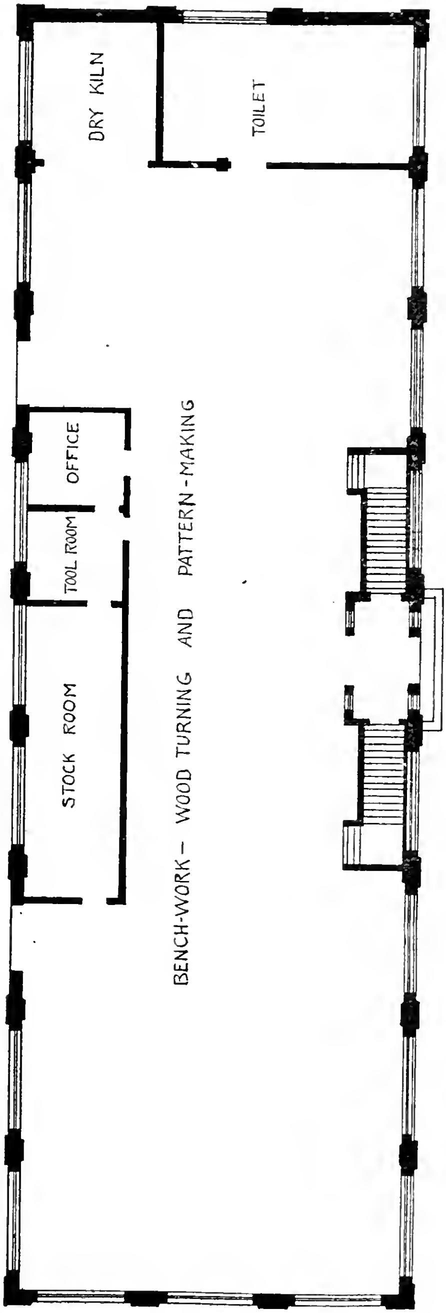


PLATE 7.—FIRST FLOOR PLAN OF SHOP NUMBER ONE.

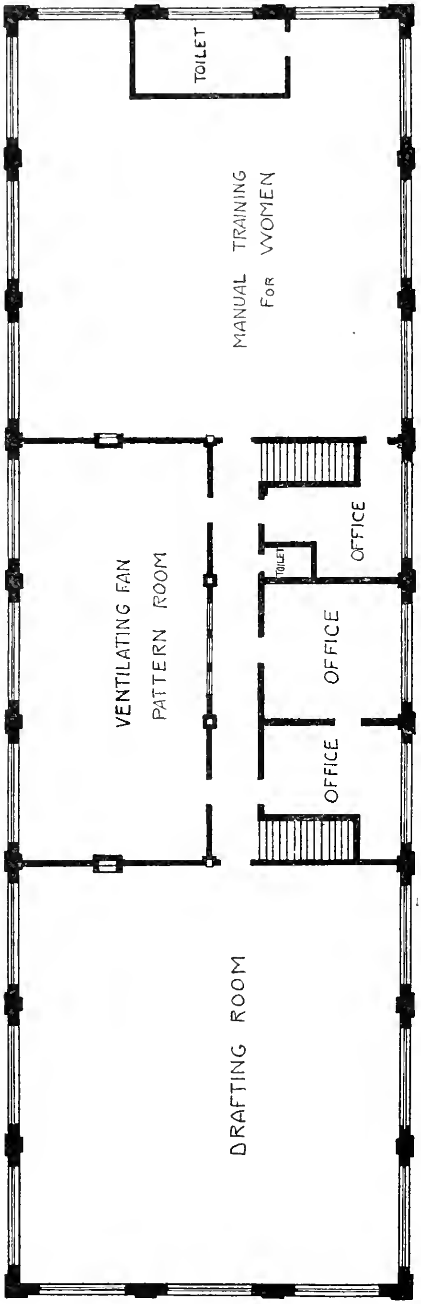


PLATE 8.—SECOND FLOOR PLAN OF SHOP NUMBER ONE.

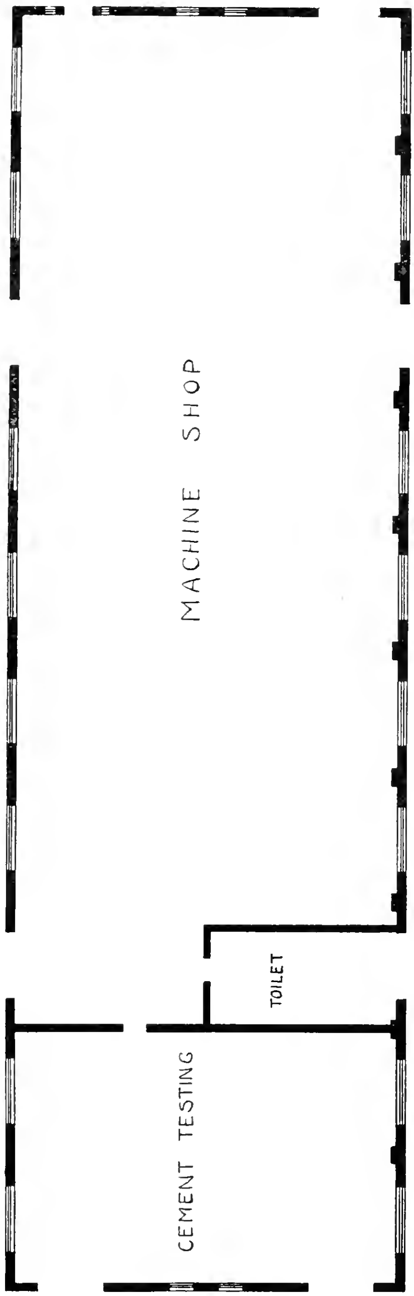


PLATE 9.—FLOOR PLAN OF SHOP NUMBER TWO.

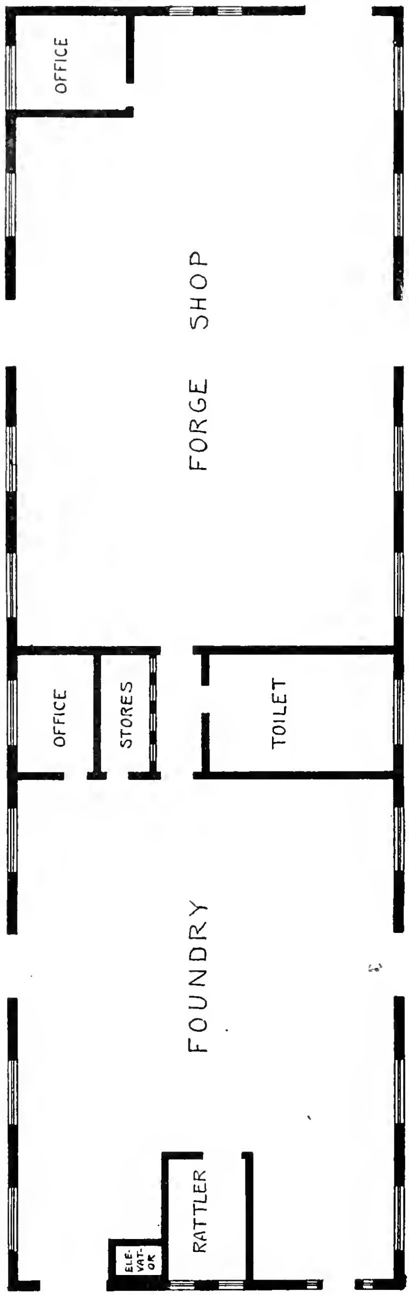
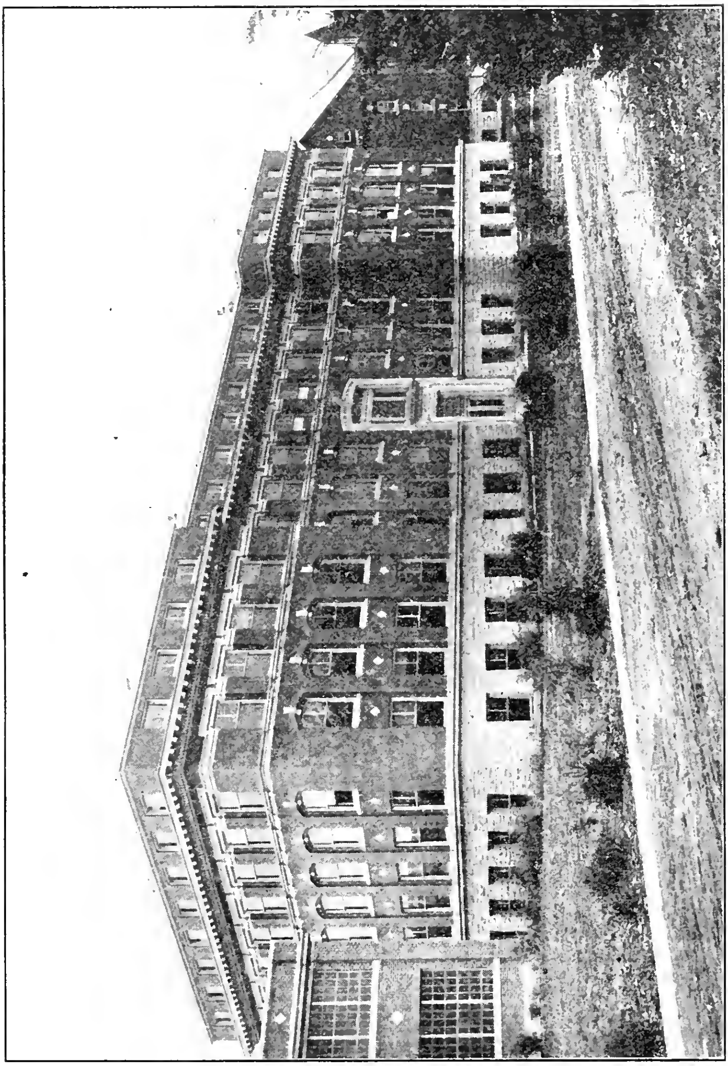


PLATE 10.—FLOOR PLAN OF SHOP NUMBER THREE.



THE R. E. OLDS HALL OF ENGINEERING.

On June 1, 1917, the afternoon of Commencement Day the new buildings were dedicated by exercises held in the Engineering Assembly Room of The R. E. Olds Hall of Engineering, according to the following program:

Presentation of the Key of the R. E. Olds Hall of Engineering ....Mr. Ransom E. Olds

Acceptance ....Dean George W. Bissell.

Greetings:

On Behalf of the Division of Agriculture..Dean Robert S. Shaw.

On Behalf of the Division of Home Economics..............
Dean Georgia L. White.

On Behalf of the Division of Home Economics ....
Mr. Lowell O. Stewart, '17.

On Behalf of the Engineering Alumni ....
Mr. Philip B. Woodworth, '86.

*Presentation of Portrait of Mr. Ransom E. Olds ....
Mr. William K. Prudden, '78.

Acceptance ....President Frank S. Kedzie.

A few days later a bronze dedicatory tablet was placed in the main entrance of The R. E. Olds Hall of Engineering. It contains the following inscription:

1917
THE R. E. OLDS HALL OF ENGINEERING
ERECTED ON THE FOUNDATIONS OF A
SIMILAR BUILDING WHICH TOGETHER WITH
THE COLLEGE SHOPS, BURNED WITH ALMOST
TOTAL LOSS OF STRUCTURES AND CONTENTS
MARCH 5, 1916.

The portrait of Mr. Olds has been permanently hung in my office.

New Equipment. In addition to the new buildings considerable new equipment has been purchased and installed and approriations for the coming year have been made for continuing the replacement of the losses from the fire. This work is necessarily slow on account of high prices, slow deliveries and the necessity of recognizing the other interests of the whole College which we gladly do, appreciating the sacrifices which

*Painted by Mr. J. H. D. Ferguson.

have been made that engineering might be reinvested with facilities for work at the earliest practical moment.

Organization. The departments and department heads for the past year are as follows:

Civil Engineering	H. K. Vedder
Drawing and Design	R. K. Steward
Electrical Engineering	A. R. Sawyer
Mechanical Engineering	J. A. Polson

The work in machine design, formerly administered by the Department of Mechanical Engineering has been this year handled by the Department of Drawing and Design and as a result of this experience the arrangement has been made permanent.

The Department of Mechanical Engineering has taken charge of the shop work in wood and iron for the agricultural students.

Personnel. The teaching staff is composed of the Dean of Engineering, four professors, two associate professors, five assistant professors and twenty-two instructors, a total of thirty-four persons.

In addition, one laboratory engineer, one mechanician, two clerks and three janitors are employed, making a total *personnel* of forty-one.

Students. The enrollment for the year is as follows:

Seniors	68
Juniors	64
Sophomores	88
Freshmen	127
Special	4
Total	384

Sixty-two were graduated on Commencement Day.

Appreciation. For myself and for the members of my staff I record sincere appreciation of the courtesies extended by the other college departments in the way of office and teaching space during our reconstruction period, particularly to those who gave up comfortable offices in Agricultural Hall for our convenience. We hope to be able to reciprocate in measure but not in kind, meaning, not because of a calamity such as befell us in the fire.

Prospects. The effect of the war on technical education in this country cannot be predicted, but I believe that every reasonable effort should be made to interest and secure young men, not called to the colors, in the idea and for the ideal of better training for usefulness—in the war if it be lasting, but in any event in the post-war time when industrial readjustment the world over will demand intelligent, energetic and enthusiastic young men in large numbers.

Respectfully submitted,

G. W. BISSELL,

Dean of Engineering.

East Lansing, Mich., June 30, 1917

REPORT OF THE DEPARTMENT OF MECHANICAL ENGINEERING.

Dr. F. S. Kedzie, President, Michigan Agricultural College.

Dear Sir—I am submitting herewith my report for the year ending June 30, 1917.

I wish at this time to record my appreciation of the rapid reconstruction of the engineering buildings lost by fire March 5, 1916. I am sure that we all appreciate the fact that so far as buildings are concerned we now have permanent structures. The three shop buildings that are under my supervision are among the best of their kind, and compare extremely well with similar shops at other institutions.

The equipment lost has been partially restored, and I hope we may be able to add more from time to time. We are most deficient in equipment in the machine shop. Several of the largest and best pieces of machinery were ruined beyond repair and have not been replaced due to lack of funds, so that we are seriously handicapped in this particular shop. In the wood shop and forge shop the equipment is practically complete and of sufficient amount to give instruction to all students taking such courses. In the foundry it would be desirable to add more equipment as soon as possible.

In the mechanical engineering laboratory we were fortunate in recovering all large pieces of machinery. These have been put into running order and seem as good as ever. The most notable change in refitting the laboratory was made in the piping arrangement; as far as possible all piping was placed below the basement floor. This adds a great deal to the appearance of the laboratory in giving clear head room.

The large fan used for ventilating the building is now placed in the laboratory, where it will be arranged for testing under regular running conditions. The elevator and elevator engine are also placed in the laboratory.

Due to the unsettled conditions it was extremely difficult to carry on the work of instruction in shops and laboratory. The senior class was the greatest sufferer in this respect. The apparatus and equipment required for senior instruction was the most difficult to get ready. I feel very grateful for the attitude shown by the students who bore the misfortune without comment.

The personnel of the department for the year was as follows:

J. A. Polson, Professor of Mechanical Engineering.
L. N. Field, Assistant Professor of Mechanical Engineering.
W. E. Reuling, Assistant Professor of Mechanical Engineering.
J. L. Morse, Instructor in Mechanical Engineering.
R. H. Bush, Instructor in Mechanical Engineering.
A. P. Krentel, Foreman of Wood Shop.
G. H. Peters, Instructor in Wood Shop.
Eugene Wood, Instructor in Wood Shop.
L. P. Hopphan, Instructor in Wood Shop.

E. A. Evans, Foreman in Machine Shop.
R. G. Bigelow, Instructor in Machine Shop.
E. T. Crossman, Assistant in Machine Shop.
J. A. Eicher, Foreman in Foundry.
John Grennan, Foreman in Forge Shop.
Andrew Watt, Instructor in Forge Shop.
E. C. Crawford, Laboratory Engineer.
J. Hineline, Laboratory Engineer.

The class work given by members of the department is tabulated as follows:

TABLE I.

Class Work of Department of Mechanical Engineering, Fall Term 1916.

Class.	Subject.	No. of course.	Teacher.	Hours per week each student.	No. of students enrolled.	Student hours per week.
Freshmen	Woodshop	2a	Mr. Krentel, Mr. Peters, Mr. Wood	6	130	780
Sophomores	Forge Shop	3a	Mr. Grennan, Mr. Watt	3	75	
Juniors	Forge Shop	3a	Mr. Grennan, Mr. Watt	3	1	231
Seniors	Forge Shop	3a	Mr. Grennan, Mr. Watt	3	1	
Sophomores	Foundry	4a	Mr. Eicher	3	81	
Juniors	Foundry	4a	Mr. Eicher	3	1	249
Seniors	Foundry	4a	Mr. Eicher	3	1	
Juniors	Machine Shop	2h	Mr. Evans, Mr. Bigelow	6	63	
Special	Machine Shop	2h	Mr. Evans, Mr. Bigelow	6	1	516
Seniors	Machine Shop	2k	Mr. Evans, Mr. Bigelow	6	22	
Sophomores	Machine Design	6a	Prof. Field, Mr. Morse	6	61	366
Juniors	Machine Design	6c	Prof. Field, Mr. Morse	6	32	192
Seniors	Gas Power Engineering	8c	Prof. Polson, Prof. Reuling	3	36	108
Juniors	Metallurgy	11a	Prof. Field, Mr. Morse	2	34	68
Seniors	Engineering Laboratory	13c	Prof. Polson, Prof. Reuling	4	60	240
Seniors	Heating and Ventilation	18a	Prof. Bissell, Prof. Reuling	3	44	132
Seniors	Costs, Accounting, etc.	18c	Prof. Bissell	2	63	126
Freshmen	Farm Mechanics	1	Mr. Krentel, Mr. Peters, Mr. Wood	6	104	624
Freshmen	Farm Mechanics	2	Mr. Grennan, Mr. Watt	6	102	
Sophomores	Farm Mechanics	2	Mr. Grennan, Mr. Watt	6	1	
Juniors	Farm Mechanics	2	Mr. Grennan, Mr. Watt	6	1	642
Seniors	Farm Mechanics	2	Mr. Grennan, Mr. Watt	6	1	
Specials	Farm Mechanics	2	Mr. Grennan, Mr. Watt	6	2	
Total					917	4,274

TABLE II.

Class Work of Department of Mechanical Engineering, Winter Term 1917.

Class.	Subject.	No. of course.	Teacher.	Hours per week each student.	No. of students enrolled.	Student hours per week.
Freshmen	Woodshop	2b	Mr. Krentel, Mr. Peters, Mr. Wood	6	112	672
Freshmen	Elements of Engineering	1	Prof. Bissell	2	109	218
Freshmen	Forge Shop	3b	Mr. Grennan, Mr. Watt	6	1	210
Sophomores	Forge Shop	3b	Mr. Grennan, Mr. Watt	6	34	
Sophomores	Foundry	4b-4c	Mr. Eicher	6	30	192
Juniors	Foundry	4b-4c	Mr. Eicher	6	2	
Sophomores	Kinematics	6b	Mr. Morse	6	19	120
Juniors	Kinematics	6b	Mr. Morse	6	1	
Sophomores	Steam Engines & Boilers	7a	Prof. Field	3	6	192
Juniors	Steam Engines & Boilers	7a	Prof. Field, Mr. Morse	3	58	
Sophomores	Machine Design	6d	Mr. Morse	3	2	87
Juniors	Machine Design	6d	Mr. Morse	3	27	
Juniors	Engineering Laboratory	13a	Prof. Reuling	4	65	260
Sophomores	Machine Shop	2i	Mr. Evans, Mr. Bigelow	6	3	504
Juniors	Machine Shop	2i	Mr. Evans, Mr. Bigelow	6	61	
Seniors	Machine Shop	2i	Mr. Evans, Mr. Bigelow	6	20	
Seniors	Engineering Laboratory	13d	Prof. Polson, Prof. Reuling	8	37	296
Seniors	Works Management	5a	Prof. Polson	3	36	108
Seniors	Steam Engine Design	8b	Prof. Field	8	24	192
Seniors	Power Station Design	18b	Prof. Bissell, Prof. Field	7	37	259
Jr. Women	Woodwork	21a	Mr. Krentel, Mr. Peters, Mr. Wood	4	9	36
Total					693	3,346

TABLE III.

Class Work of Department of Mechanical Engineering, Spring Term 1917.

Class.	Subject.	No. of course.	Teacher.	Hours per week each student.	No. of students enrolled.	Student hours per week.
Freshmen	Woodshop	2c	Mr. Krentel, Mr. Peters, Mr. Wood	6	83	498
Sophomores	Forge Shop	3b-3c	Mr. Grennan, Mr. Watt	6	27	186
Juniors	Forge Shop	3b-3c	Mr. Grennan, Mr. Watt	6	4	
Sophomores	Foundry	4b-4c	Mr. Eicher	6	32	204
Juniors	Foundry	4b-4c	Mr. Eicher	6	2	
Sophomores	Machine Shop	2j	Mr. Evans, Mr. Bigelow	6	8	210
Juniors	Machine Shop	2j	Mr. Evans, Mr. Bigelow	6	27	
Juniors	Thermodynamics	17a	Prof. Bissell, Prof. Polson, Prof. Field	4	65	296
Seniors	Thermodynamics	17a	Prof. Field	4	9	
Juniors	Engineering Laboratory	13b	Prof. Polson, Prof. Reuling	4	66	268
Seniors	Engineering Laboratory	13b	Prof. Polson, Prof. Reuling	4	1	
Juniors	Steam Engine Design	8a	Prof. Field, Mr. Morse	4	25	112
Seniors	Steam Engine Design	8a	Prof. Field, Mr. Morse	4	3	
Freshmen	Mechanical Drawing	3a	Mr. Morse	10	21	210
Seniors	Jig Design	6e	Prof. Field	6	22	132
Seniors	Thesis	19a	Prof. Polson, Prof. Field	20	17	340
Freshmen	Farm Mechanics	2	Mr. Grennan, Mr. Watt	6	79	492
Sophomores	Farm Mechanics	2	Mr. Grennan, Mr. Watt	6	2	
Juniors	Farm Mechanics	2	Mr. Grennan, Mr. Watt	6	1	
Freshmen	Farm Mechanics	1	Mr. Krentel, Mr. Peters, Mr. Wood	6	65	390
Jr. Women	Woodwork	21b	Mr. Krentel, Mr. Peters, Mr. Wood	4	7	28
Total					566	3,366

At the beginning of the school year the work of instruction in Farm Mechanics 1 and 2 (wood work and forge work) was transferred to this department.

During the year the department has received many favors from several Lansing manufacturers, especially the Reo Motor Car Co., The Reliance Engineering Co., Bates & Edmonds Motor Co., and others. Some companies loaned us equipment and others gave us castings.

Everyone connected with the department appreciates to the fullest extent all that has been done during the past year, and in no way do I wish to give voice to anything of a different nature. So far as buildings are concerned the department is fully provided for, but when it comes to equipment there is still a great deal to desire. I realize as well as anyone that we cannot have all we desire now or in the near future, and perhaps never. In the eleven years that I have been connected with this department we have never had anywhere near what was urgently needed along the line of equipment.

Mechanical engineering is a profession that is built up by combining theory and practice. These are so closely connected that nothing real can be accomplished by either alone. In the final application of engineering theory to any actual problem we find that every formula contains one or more experimental or practical constants, which means that not a single piece of apparatus or machine can be built unless you have secured experimental data. In the ordinary, everyday class of work practically all necessary data have been secured and are easily available. But we have by no means reached the end. New conditions, new material, new designs are constantly being developed, hence the need for experimental work continues.

Great importance must therefore be attached to equipment necessary in the mechanical engineering laboratory.

In the hope that I may impress upon you the urgent necessity of increasing our equipment at the very earliest time, I am submitting herewith a general outline of our requirements:

MECHANICAL ENGINEERING LABORATORY.

1. Two 35 or 40 H. P., cradle, electric dynamometers. I consider this the most important item of all for the coming year. This testing set can be used for testing all kinds of power transmission, as, for example, belt testing, the testing of gear drives and friction drives, determining the efficiency of universal couplings, and almost an unlimited amount of transmission apparatus.

II. Inasmuch as Michigan manufactures more automobiles than any other state in the Union, I believe it our duty to offer instruction in some phase of automobile engineering. The most important phase of automobile engineering would involve equipment for testing engines. The same equipment could be used for testing aeroplane engines, marine engines or high speed engines for any purpose. The trend of automobile and aeroplane engines is to increase the speed and power. The equipment necessary for this work would be an automobile engine testing outfit that would have a capacity of at least 150 H. P. at 4,000 revolutions.

III. The importance of oil engines need not be emphasized. Everybody knows that gasoline engines and internal combustion engines in general are playing a very important part in the World War. Due to

the high price of gasoline, manufacturers of every type of engine are endeavoring to find means for using kerosene or even less refined oil. For that reason it is desirable to have a good type of crude oil engine in the laboratory.

IV. In power plant work we find that the steam turbine has come to the front with enormous strides. Steam turbines are now being built up to 35,000 kilowatts (50,000 H. P.) in one unit. The turbine that we installed a short time ago is an excellent piece of apparatus to bring out the behavior of a steam turbine. In order that this may be better brought out it is desirable to install a superheater so that steam may be supplied with predetermined amounts of superheat in order that the efficiency may be determined under the various conditions. The modern steam turbine as now installed in power plants could not approach its present performance without the use of superheat.

V. One of the discouraging things to teachers of mechanical engineering is the fact that there is practically no opportunity for them to carry on advanced experimental or research work. We have nothing that compares with the research work carried on by the agricultural experiment stations. The benefits to the community would be just as great. There are many lines of investigation possible. I will mention only one that presents itself very strongly at this time, namely, the fuel problem.

There are two distinct phases of this problem, both just now being influenced by the high cost of coal. From the standpoint of the power plant operator it will be necessary to improve the combustion end of his apparatus before any marked gain can be made in economy. From the standpoint of domestic heating it will be necessary to increase the efficiency of our heating units in order to lessen the cost of heating. Increased efficiency in the above lines will save money for the people of the state and conserve our fuel supply.

Experimental work should be undertaken at once to increase the use of Michigan coal. If means were available for burning Michigan coal, it would mean a great deal to the people of the state.

Work of this kind would be of a very stimulating nature for the teachers in the department.

SHOPS.

The position that should be taken by the college shop is considered rather a mooted one by some authorities. It is a fact that many college shops do not give instruction and work comparable to a good manual training or trade school. The manual training schools and trade schools have attacked the problem from a little different view point than the colleges. A large number of their students do not expect to go to college, but they learn as much of a trade as they can and then enter the shop or factory to put it into practice, and the better schools come very close to meeting this requirement. Inasmuch as the colleges and universities do not expect their graduates to become mechanics, but engineers, you can see how shop work has been neglected. A certain amount of shop work is essential so that students in engineering may understand the processes that are used in various manufactures.

The important thing today, to my mind, seems to be the teaching of management and methods of reducing cost of production in addition

to the training given by the use of tools and machinery. For that reason I consider the most important problem that we have in connection with the shops is to develop the system of management that I have referred to from time to time. Briefly, this system would involve the installation of whatever means will be necessary to carry on the work of the four shops on a businesslike basis. I believe the best way to tackle this problem is to conduct the shops as nearly like a manufacturing plant as is consistent with conditions. My idea would be to have all underclassmen carry on their work as outlined by the system that would be installed. Proper orders should be issued for the production of patterns, castings and machine work. Records should show the amount of time used by the student to do his work, the work should be inspected and passed upon finally by some instructor in charge, and the final results should be known, i. e., how many pieces are spoiled and lost from various reasons. The underclassmen would carry on the work under this system without knowing how the system was run. They would simply follow instructions given them. In the senior year a large portion of the time assigned to mechanical engineers would be devoted to helping carry on the system. In that way they would become familiar with the working of the system from both sides, i. e., they would know how it works out by having worked under it as underclassmen, and they would know how the system was conducted and carried on by helping to do so in the senior year.

The development of a system of this kind must necessarily be slow. At the University of Illinois, where funds were unlimited, Professor C. R. Richards told me that it had taken them four years. In various factories where the Taylor system and other systems have been installed in actual cases the time runs from three to five years.

It is difficult to impress upon the average man the vast importance of proper shop management and how it will bring about increased production and decreased cost.

Many college men do not like to take up the shop end of engineering work when they leave college, but the shop end offers more opportunities for advancement and compensation than the engineering office in a manufacturing establishment. Many of our recent graduates have gone directly into the shop in production work. With proper training in shop management given them in our shops many more would take up this line of work.

PATTERN SHOP.

The equipment in the pattern shop is fairly complete. We need a surfacer, a power mortiser, a swing saw and a dust collecting system.

It would be very desirable to give advanced work in pattern making, especially in metal patterns. Metal patterns are made largely of brass and aluminum. Due to the high price of these metals it is out of the question with our limited funds.

FORGE SHOP.

So far as the requirements for regular class work are concerned, the equipment is complete. However, it is extremely desirable to emphasize manufacturing forging methods. It is probably out of the question to

do anything along the line of drop forging, but it would be entirely practical to do machine forging.

To mention only one line of work that might be done, we have a great deal of iron and steel scrap in short rods that accumulates from various sources. These scrap rods could be worked up into forged bolts and nuts. There is enough scrap available to supply all bolts and nuts used by the shops and power plant. This machine would give the students experience in setting up and operating on a production basis, also give the opportunity to make and try out various forms of dies. This would give them a chance to see that the dies were properly hardened. If a die would stand up in actual service, everyone would feel that it was properly made.

MACHINE SHOP.

Modern machine tools are now made as largely automatic as possible. There are several reasons for the introduction of automatic machinery in modern shops. An automatic machine will do its work without the human element. Automatic machines are set up by machine setters, and all that is necessary of the operator is to supply more stock. Automatic machinery is typical of the highest class of machine tool design. The skill of the designer is transferred to the machine. Automatic machinery can be run by unskilled labor, which is more plentiful and less costly than skilled labor.

We have no type of automatic machine in our machine shop; it would, therefore, be extremely desirable to install an automatic turret lathe. It would bring out the points mentioned above; it would give the student the opportunity of setting up this machine for doing whatever work was at hand. The bolts and nuts made by the forge shop would be threaded on this machine. The student would get the benefit of setting up this machine for threading any particular size of bolt or nut that would be required, and his experience in setting up would be had even if he made only a dozen bolts. The various cams and other automatic features of the machine would in that way be brought directly to the student's attention, and the experience is very desirable.

I do not agree with the idea that the automatic machine is undesirable because it is suitable only for devouring stock. As actually used in the factory that is what the machine is for. It is run by unskilled labor, and the quantities produced on the machine at one setting vary from 5,000 to 100,000 or more, as, for example, machines used in the Michigan Screw Company. They are set up only when a large order is required, and then run continuously night and day until that order is filled. Of course it would not be desirable to use the machine in our shop in that way, and that is why I say that the student would get the benefit of setting up the machine and operating it even if he produced only a dozen pieces. The next student that came along would be given the job of setting up the machine for a different type of piece, and in that way get his experience in setting up and operating.

A universal tool grinder is urgently needed in order that advanced tool making may be given. We also need a vertical boring mill, a universal milling machine, a small punch press and a number of small hand tools.

FOUNDRY.

In the foundry we need equipment for studying the technical side of metal founding. Equipment is necessary for testing molding sand, core sand and core mixtures, and for studying the behavior of the cupola and method of control. A sand blast is necessary for cleaning castings, a furnace for melting brass and aluminum and instruments for temperature control. In order to teach manufacturing methods it is desirable to have several types of molding machines.

This by no means exhausts the list of desirable apparatus, but I sincerely hope that means may be found to increase the equipment and apparatus to a point where they will compare favorably with the excellent buildings.

Yours truly,
J. A. POLSON,
Professor of Mechanical Engineering.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF CIVIL ENGINEERING.

President F. S. Kedzie,

Dear Sir—A record of departmental activities for the year 1916-1917 is herewith presented. This period constitutes the first full college year since the destructive fire of 1916, the effects of which have been oppressively apparent in our lack of equipment necessary for the most efficient results of our teaching.

In some of our field and laboratory classes it has been necessary to substitute makeshift apparatus and in a few instances to materially change the character of the training attempted. It is to be hoped that our facilities may be substantially improved for the coming year. Of the most pressing importance in this line is the need of a hydraulic laboratory. Only slightly less necessary is additional instrumental equipment for surveying and for our laboratory which deals with the construction, use and adjustment of precision instruments. A third necessity is proper provision for the storage of instrumental equipment. A room has been set apart in the new Engineering Building for this purpose, but as yet its furniture includes only a few shelves and temporary racks built by the instructors.

The department continued to use office space and class rooms in the Agricultural Building until the opening of the spring term of 1917, when it became possible to occupy quarters in the new R. E. Olds Hall of Engineering.

The department teaching staff shows only one change when compared with my report of last year. Mr. H. I. Davies declined a reappointment, and the position was filled by the engagement of Mr. H. M. Ward, an engineering graduate of M. A. C., class of 1913. All teachers in the department have given satisfactory service and in many cases have responded to unusual demands. The following list includes the names

of all who shared the year's work, tabulated in the order of seniority of appointment:

H. K. Vedder, C. E., Professor of Civil Engineering.
C. A. Melick, D. C. E., Associate Professor of Civil Engineering.
C. M. Cade, C. E., Assistant Professor of Civil Engineering.
R. G. Saxton, C. E., Assistant Professor of Civil Engineering.
W. W. Hitchcock, C. E., Instructor in Civil Engineering.
B. K. Philp, C. E., Instructor in Civil Engineering.
H. A. Gehring, C. E., Assistant Professor of Civil Engineering.
H. M. Ward, B. S., Instructor in Civil Engineering.

The tabulation below exhibits in convenient form for reference the data of class attendance in the department during the year. The direction of classes is here shown according to the assignments as made at the beginning of the several terms. On account of illness among the teachers there were numerous disarrangements of the scheduled plan, and several instructors undertook much more than their allotment of class work for considerable periods. I may note that sickness kept me from the class room a week, the only case in which an absence of such duration has been chargeable to my account in my twenty-six years of service at this college.

CLASS WORK OF THE DEPARTMENT OF CIVIL ENGINEERING FOR THE COLLEGE YEAR 1916-1917.

Class.	Subject.	No. of course.	Teacher.	Class room.	Periods of meeting.	No. hours per week.	No. students in class.
Summer Sch. 1916 (2 weeks) Juniors	Forest Topography	C.E.2a.	Prof. Cade	14 miles n. w. of Cadillac Michigan.	....	50	7
Fall term.							
Sophomores.	Surveying (class)	C.E. 1a.	Prof. Saxton	206 A. H.	5	2	24
Sophomores.	Surveying (class)	C.E. 1a.	Prof. Gehring	213 A. H.	7	2	21
Sophomores.	Surveying (class)	C.E. 1a.	Mr. Ward	213 A. H.	5	2	17
Sophomores.	Surveying (class)	C.E. 1a.	Mr. Ward	403 A. H.	1	2	23
Sophomores.	Surveying (class)	C.E. 1a.	Mr. Ward	Bot. Lec. R.	3	2	20
Sophomores.	Surveying (class)	C.E. 1a.	Mr. Hitchcock	208 A. H.	7	2	20
Sophomores.	Surveying (class)	C.E. 1a.	Mr. Hitchcock	206 A. H.	1	2	16
Sophomores.	Surveying (class)	C.E. 1a.	Mr. Hitchcock	206 A. H.	3	2	32
Sophomores.	Surveying (field)	C.E. 1a.	Mr. Hitchcock, Mr. Philp	....	3, 4	2	30
Sophomores.	Surveying (field)	C.E. 1a.	Mr. Hitchcock, Mr. Philp	....	3, 4	2	17
Sophomores.	Surveying (field)	C.E. 1a.	Mr. Ward	....	7, 8	2	19
Sophomores.	Surveying (field)	C.E. 1a.	Mr. Ward	....	7, 8	2	18
Sophomores.	Surveying (field)	C.E. 1a.	Mr. Ward	....	5, 6	2	20
Sophomores.	Surveying (field)	C.E. 1a.	Mr. Ward	....	5, 6	2	19
Sophomores.	Surveying (field)	C.E. 1a.	Mr. Ward	....	1, 2	2	24
Sophomores.	Surveying (field)	C.E. 1a.	Mr. Ward	....	1, 2	2	21
Juniors	Mechanics	C.E. 4a.	Prof. Gehring	110 A. H.	1	5	10
Juniors	Mechanics	C.E. 4a.	Prof. Melick	208 A. H.	5	5	9
Juniors	Mechanics	C.E. 4a.	Prof. Saxton	400 A. H.	1	5	12
Juniors	Mechanics	C.E. 4a.	Mr. Philp	207 A. H.	1	5	14
Juniors	Mechanics	C.E. 4a.	Mr. Philp	207 A. H.	5	5	9
Juniors	Mechanics	C.E. 4a.	Mr. Hitchcock	316 A. H.	5	5	10
Juniors	Adv. Surveying (class)	C.E. 6.	Prof. Melick	207 A. H.	7	3	17
Juniors	Adv. Surveying (class)	C.E. 6.	Prof. Melick	207 A. H.	8	3	15
Juniors	Adv. Surveying (class)	C.E. 6.	Mr. Philp	213 A. H.	2	3	15
Juniors	Adv. Surveying (class)	C.E. 6.	Mr. Hitchcock	400 A. H.	2	3	21
Juniors	Adv. Surveying (field)	C.E. 6.	Prof. Cade, Mr. Hitchcock	....	6, 7	4	19
Juniors	Adv. Surveying (field)	C.E. 6.	Prof. Melick, Prof. Cade	....	3, 4	4	17
Juniors	Adv. Surveying (field)	C.E. 6.	Prof. Melick, Prof. Cade	....	3, 4	4	15
Juniors	Adv. Surveying (field)	C.E. 6.	Mr. Philp	....	6, 7	4	15
Jun. Sen.	Survey'g Methods (class)	C.E. 2.	Prof. Cade	208 A. H.	1	3	13
Jun. Sen.	Survey'g Methods (field)	C.E. 2.	Prof. Cade	....	1, 2	4	13
Seniors	Graphic Statics	C.E. 4d.	Prof. Melick	213 A. H.	1	3	19
Seniors	Graphic Statics	C.E. 4d.	Prof. Melick	208 A. H.	2	3	11
Seniors	Hydraulics	C.E. 5.	Prof. Saxton	207 A. H.	3	5	12
Seniors	Hydraulics	C.E. 5.	Prof. Gehring	208 A. H.	3	5	16
Seniors	Hydraulics	C.E. 5.	Prof. Saxton	207 A. H.	4	5	23
Seniors	Hydraulics	C.E. 5.	Prof. Gehring	208 A. H.	4	5	15
Seniors	Hydraulic Laboratory	C.E. 5a.	Prof. Saxton	403 A. H.	5–8	4	8
Seniors	Hydraulic Laboratory	C.E. 5a.	Prof. Saxton	403 A. H.	5–8	4	8
Seniors	Hydraulic Laboratory	C.E. 5a.	Prof. Gehring	403 A. H.	5–8 T	4	10
Seniors	Hydraulic Laboratory	C.E. 5a.	Prof. Gehring	403 A. H.	5–8 Th	4	10
Seniors	Higher Survey (class)	C.E. 6b.	Prof. Vedder	400 A. H.	1	1	14
Seniors	Higher Survey (class)	C.E. 6b.	Prof. Vedder	314 A. H.	4	1	15
Seniors	Higher Survey (field)	C.E. 6b.	Prof. Vedder, Prof. Cade	....	5–8 Th	4	14
Seniors	Higher Survey (field)	C.E. 6b.	Prof. Vedder, Prof. Cade	....	5–8 W	4	15
Seniors	Bridge Stresses	C.E. 8a	Prof. Vedder	207 A. H.	2	3	13
Seniors	Bridge Stresses	C.E. 8a.	Prof. Vedder	400 A. H.	4	3	17

WINTER TERM, 1917.

Class.	Subject.	No. of course.	Teacher.	Class room.	Periods of meeting.	No. hours per week.	No. students in class.
Juniors....	Mechanics..............	C.E. 4b.	Mr. Philp..................	208 A. H...	1	5	13
Juniors.....	Mechanics..............	C.E. 4b.	Prof. Cade..................	403 A. H...	1	5	10
Juniors....	Mechanics..............	C.E. 4b.	Prof. Saxton................	403 A. H...	5	5	11
Juniors....	Mechanics..............	C.E. 4b.	Mr. Philp..................	207 A. H...	5	5	10
Juniors.....	Mechanics..............	C.E. 4b.	Mr. Hitchcock..............	311 A. H...	1	5	8
Juniors.....	Mechanics..............	C.E. 4b.	Mr. Hitchcock..............	208 A. H...	5	5	12
Juniors.....	Topographic Mapping....	Dr. 6..	Mr. Ward..................	Shop No. 1.	3, 4	6	11
Juniors....	Topographic Mapping....	Dr. 6..	Mr. Ward..................	Shop No. 1.	7 8T. Th 1, 2, S	6	16
Jun., Sen...	Agricultural Engineering..	C.E. 3..	Prof. Vedder..............	207 A. H...	2	5	16
Seniors.....	Bridge Anal. & Design...	C.E. 8b.	Prof. Melick, Mr. Philp......	Shop No. 1.	3, 4	8	28
Seniors.....	Masonry & Arches.......	C.E. 9..	Prof. Melick................	110 A. H...	5	3	14
Seniors.....	Masonry & Arches.......	C.E. 9..	Prof. Gehring..............	207 A. H...	1	3	13
Seniors.....	Masonry & Arches (Lab.)	C. E. 9.	Prof. Melick, Prof. Gehring...	Shop No. 1.	7, 8, T.Th	4	14
Seniors....	Masonry & Arches (Lab.)	C.E. 9.	Prof. Melick, Prof. Gehring...	Shop No. 1.	3,4&7,8,F.	4	14
Seniors.....	Pavements.............	C.E. 10.	Prof. Saxton................	207 A. H...	7	2	15
Seniors....	Pavements.............	C.E. 10.	Prof. Saxton................	207 A. H...	1	2	13
Seniors.....	Experimental Laborat'y.	C.E. 12.	Prof. Cade, Mr. Hitchcock.	Cement Lab. & 403 A. H.	6-7-8 M.W.	6	15
Seniors.....	Experimental Laborat'y.	C.E. 12.	Prof. Cade, Prof. Saxton....	Cement Lab. & 403 A.H.	2-3-4 6-7-8 F.	6	13
Seniors....	Water Supply...........	C.E. 15.	Prof. Gehring..............	208 A. H...	2	4	14
Seniors.....	Water Supply...........	C.E. 15.	Prof Saxton................	403 A. H...	2	4	14

SPRING TERM, 1917.

Class.	Subject.	No. of course.	Teacher.	Class room.	Periods of meeting.	No. hours per week.	No. students in class.
Sophomores.	Surveying (class)........	C.E. 1b.	Mr. Ward..................	208 A. H...	8	2	21
Sophomores.	Surveying (class)........	C.E. 1b.	Mr. Ward..................	208 A. H...	7	2	20
Sophomores.	Surveying (class)........	C.E. 1b.	Mr. Hitchcock..............	109 A. H...	3	2	16
Sophomores.	Surveying (class)........	C.E. 1b.	Mr. Hitchcock..............	207 A. H...	4	2	21
Sophomores.	Surveying (field)........	C.E. 1b.	Mr. Ward, Mr. Hitchcock....	....	3,4,7,8, F	4	16
Sophomores.	Surveying (field)........	C.E. 1b.	Mr. Ward, Mr. Hitchcock....	....	1, 2	4	18
Sophomores.	Surveying (field)........	C.E. 1b.	Mr. Ward, Mr. Hitchcock....	....	1, 2	4	25
Sophomores.	Surveying (field).........	C.E. 1b.	Mr. Ward..................	....	5, 6	4	18
Sophomores.	Survey'g Methods (class)	C. E.2..	Prof. Cade................	403 M. W. 314 F.	4 2	3	13
Sophomores.	Survey'g Methods (field).	C.E. 2..	Mr. Philp..................	....	1, 2	4	13
Juniors.....	Topographic Map. (class)	C.E. 6a.	Prof. Cade..................	105 R.E.O...	8	2	11
Juniors.....	Topographic Map. (class)	C.E. 6a.	Prof. Cade..................	105 R.E.O..	2	2	18
Juniors.....	Topographic Map. (field)	C.E. 6a.	Prof. Cade, Prof. Gehring....	....	1, 2	4	18
Juniors.....	Topographic Map. (field)	C.E. 6a.	Prof. Cade, Mr. Philp........	....	7, 8	4	11
Juniors.....	Strength of Materials....	C.E. 4c.	Mr. Philp..................	110 A. H...	3	5	11
Juniors.....	Strength of Materials....	C.E. 4c.	Mr. Philp..................	109 A. H...	4	5	13
Juniors.....	Strength of Materials....	C.E. 4c.	Mr. Philp..................	208 A. H...	6	5	7
Juniors.....	Strength of Materials....	C.E. 4c.	Prof. Gehring..............	208 A. H...	3	5	13
Juniors.....	Strength of Materials....	C.E. 4c.	Prof. Gehring..............	115 R.E.O..	6	5	7
Juniors.....	Strength of Materials....	C.E. 4c.	Prof. Gehring..............	105 R.E.O..	5	5	16
Juniors.....	Railroad Survey (class)...	C.E. 7..	Prof. Melick................	105 R.E.O..	1	3	24
Juniors.....	Railroad Survey (class)..	C.E. 7..	Prof. Melick................	105 R.E.O..	7	3	11
Juniors.....	Railroad Survey (field)...	C.E. 7..	Prof. Melick, Prof. Saxton....	....	5-8 W	4	16
Juniors.....	Railroad Survey (field)...	C.E. 7..	Prof. Melick, Prof. Saxton....	....	1-4 S.	4	19
Jun., Sen...	Roads (class)...........	C.E. 17.	Prof. Saxton................	315 A. H....	4	2	6
Jun., Sen...	Roads (field)...........	C.E. 17.	Prof. Saxton, Prof. Melick....	....	3, 4	6	6
Seniors.....	Contracts, etc...........	C.E. 13.	Prof. Vedder................	105 R.E.O..	3	3	30
Seniors.....	Contracts, etc...........	C.E. 13.	Prof. Vedder................	105 R.E.O..	4	3	32
Seniors.....	Astronomy (class).......	C.E. 14.	Prof. Vedder................	105 R.E.O..	4	2	28
Seniors.....	Astronomy (field).......	C.E. 14.	Prof. Vedder, Mr. Philp......	....	Evening..	2	28
Seniors.....	Thesis, 4 sections........	C.E. 11.	Prof. Vedder, Prof. Melick... Prof. Gehring, Prof. Cade...	....	....	20	26

The following text-books have been used in our classes during the year: Merriman & Jacoby's Roofs and Bridges, Vols. I, II, III; Vedder's Notes on Surveying; Daugherty's Hydraulics; Hancock's Mechanics; Baker's Masonry Construction; Harger and Bonney's Highway Engineer's Handbook; Turneaure and Russel's Public Water Supplies; Folwell's Sewerage; Hosmer's Astronomy; Tucker's Contracts in Engineering; Boyd's Strength of Materials; Allen's Railroad Curves and Earthworks; Breed and Hosmer's Surveying, Vols. I, II; Ingram's Geodetic Surveying; Blanchard and Drowne's Highway Engineering.

The total expenditure by the department during the year for all purposes has been $9,081.26. During the same period the sum of $595.00 has been turned in for class and examination fees, and we have been credited with $4.50 on inter-departmental requisitions.

Respectfully submitted,

H. K. VEDDER,

Professor of Civil Engineering.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF ELECTRICAL ENGINEERING.

President F. S. Kedzie, College.

Dear Sir—The main effort of the department this year has been to keep the usual classes in operation despite the lack of permanent quarters.

On Jan. 1st we began holding laboratory classes in the new building—R. E. Olds Hall of Engineering—and since April 9 at the opening of the spring term, have held all of our scheduled classes in this building. The contractor, Mr. F. C. Trier, deserves our hearty thanks for allowing us to use the first two floors while construction was going on.

During the fall term we were unable to hold one laboratory class until Dec. 1st, because of the lack of a building, but this was replaced by a recitational course until room was provided; otherwise the work of the year has been carried out as per schedule—athough under disadvantages.

Since the creation of the Department of Electrical Engineering, Mr. Cory and myself have been the only two salaried members. Jan. 1, 1917 Mr. W. S. Fox and Mr. H. J. Knowlton were employed by the month to assist with the work. The former was engaged more particularly to prepare apparatus that would be needed during the winter and spring terms; the latter to assist with class work.

At the faculty meeting in Dec. 1916, an increase in the number of electrical options was authorized, which makes it possible for those wishing to specialize in electrical work, to get more in that line than has been included in the course heretofore.

The elections of the sophomores this spring for next year as juniors, indicated that this increase in the number of options is appreciated.

During the spring term the department has been working with Mr. D. A. Seeley in developing an electrical method of determining tem-

perature differences, which can be applied to measuring plant leaf temperatures. This work is considered to have an important bearing in the matter of studying how plants grow, and we have met with considerable success in measuring small differences of temperatures.

Very respectfully submitted,

A. R. SAWYER,

Professor of Electrical Engineering.

East Lansing, Mich., June 30, 1017.

REPORT OF THE DEPARTMENT OF DRAWING AND DESIGN.

President F. S. Kedzie,

Dear Sir—I herewith present to you my first annual report as head of the Department of Drawing and Design for the year ending June 30, 1917.

The personnel of the department at the opening of the college year was as follows:

Mr. Chace Newman, Associate Professor of Drawing and Design.
Miss Caroline L. Holt, Instructor.
Mr. Frank D. Messenger, Instructor.
Mr. Alfred Iddles, Instructor.
Mr. Earle H. Stewart, Instructor.
Mr. Lawrence N. Field, Assistant Professor of Mechanical Engineering.
Mr. James L. Morse, Instructor in Mechanical Engineering.

Miss Holt was absent on leave during the winter term and spent the time studying at the Chicago Art Institute.

Mr. Chapin was appointed for the spring term having been absent during the fall and winter terms studying at the University of Chicago.

The work of the department was carried on throughout the year in various buildings on the campus and I wish to thank the different departments for the cooperation which they have extended to me.

As a result of the fire our entire file of course outlines, and teaching material was lost. This has materially increased the labors of each individual over and above his or her regular teaching schedule. In this connection I would like to express my deep appreciation for the uniform support which I have received from the members of the staff. I feel that a large amount of credit is due the different individuals for the organization which we have built up during the year. Each person has been assigned certain duties in connection with the reorganization of the department and I have found them all willing to respond.

Throughout the year the work in Machine Design has been under my supervision. This embraces the following courses: M. E. 6a, 6b, 6c, 6d, 6e, 6f, 8a, 8b. These courses have been handled by Mr. Field, Mr. Morse, Mr. Iddles and Mr. Stewart. The above mentioned change places all the drawing and design work under one head and will lead to more

uniform practice throughout the four years of a student's course. As a result of this change Mr. Field and Mr. Morse have been transferred to the staff of the Department of Drawing and Design, and the courses listed above as M. E. 6a, 6b, etc., now appear in the 1916-17 catalog as D. & D. 6a, 6b, etc.

During the winter term D. & D. 2b, History of Art was omitted on account of the loss of equipment necessary to conduct such a course.

Domestic Art 7 was divided during the winter term in the following manner. The first eight weeks' work was under the supervision of the Drawing department and the last four weeks under the Home Economics division. The purpose of this change was to so divide the work that the Drawing department could give all of the lectures and instruction on heating, lighting, ventilation, plumbing, water supply, drainage, and also the drawing of house plans including the study of floor plans, elevations, interior details, architectural effects, bills of materials and specifications. Such a division of the work proved very satisfactory and in the 1916-17 catalog a course is now offered in House Architecture known as D. & D. 9. Along this same line I feel that there is an opportunity to develop a course of a practical nature to be elective for the men students and I expect to submit an outline for such a course in the near future.

During the year the department has designed outlines and problems for twenty-two courses and now has on file for reference an outline of each course taught. In addition to this each member of the staff has had an active part in planning the equipment of the new quarters to be occupied by the department in the R. E. Olds Hall of Engineering. In this building storage cabinets have been made for student drawings, and designs are completed for the full equipment of the freehand drawing rooms.

A committee has obtained from local manufacturing plants a very fair collection of machine parts to be used by the engineers in making freehand machine sketches.

The Blue Printing department will be fully equipped and ready for business at the beginning of the fall term.

The following is the teaching schedule of the department.

Respectfully submitted,

R. K. STEWARD,

Professor of Drawing and Design.

East Lansing, Mich., June 30, 1917.

TEACHING SCHEDULE DEPARTMENT OF DRAWING AND DESIGN.

FALL TERM, 1916.

Class.	Subject.	No.	Teacher.	Hours per w'k each student.	No. students in class.
Freshmen	Mechanical Drawing	4 ab-1	Mr. Stewart	6	17
Freshmen	Mechanical Drawing	4 ab-2	Mr. Messenger	6	17
Freshmen	Mechanical Drawing	4 ab-3	Mr. Messenger	6	15
Freshmen	Mechanical Drawing	4 ab-4	Prof. Steward	6	15
Freshmen	Mechanical Drawing	4 ab-5	Mr. Messenger	6	15
Freshmen	Mechanical Drawing	4 ab-6	Mr Stewart	6	17
Freshmen	Mechanical Drawing	4 ab-7	Mr. Stewart	6	17
Freshmen	Mechanical Drawing	4 ab-8	Prof. Steward	6	18
Sophomores	Freehand	1 b-1 2	Miss Holt	10	14
Sophomores	Freehand	1 b-3 4	Miss Holt	10	32
Sophomores	Descriptive Geometry	5 ab	Prof. Steward	8	8
Sophomores	Machine Design	6a-1	Prof. Field	6	25
Sophomores	Machine Design	6a-2	Mr. Morse	6	18
Sophomores	Machine Design	6a-3	Mr. Morse	6	21
Sophomores	Machine Design	6a-4	Mr. Iddles	6	23
Juniors	Shades Shadows and Perspective	7-1 2	Prof. Newman	6	16
Juniors	Shades Shadows and Perspective	7-3 4	Mr. Messenger	6	15
Juniors	Machine Design	6c-1 2	Mr. Morse	6	16
Juniors	Machine Design	6c-3 4	Prof. Field	6	15
Juniors and Seniors	Freehand	1c	Prof. Newman	10	15
Total					349

WINTER TERM, 1917.

Class.	Subject.	No.	Teacher.	Hours per w'k each student.	No. students in class.
Freshmen	Mechanical Drawing	4e-1	Mr. Stewart	6	10
Freshmen	Mechanical Drawing	4e-2	Mr. Stewart	6	10
Freshmen	Mechanical Drawing	4e-3	Mr. Stewart	6	19
Freshmen	Mechanical Drawing	4e-4	Mr. Iddles	6	13
Freshmen	Mechanical Drawing	4e-5	Mr. Stewart	6	12
Freshmen	Mechanical Drawing	4e-6	Mr. Messenger	6	14
Freshmen	Mechanical Drawing	4e-7	Mr. Messenger	6	11
Freshmen	Mechanical Drawing	4e-8	Prof. Steward	6	12
Sophomores	Machine Design	6b-1	Mr. Stewart	6	14
Sophomores	Machine Design	6b-2	Mr. Iddles	6	21
Sophomores	Machine Design	6b-3	Mr. Morse	6	21
Sophomores	Machine Design	6b-4	Mr. Iddles	6	23
Juniors	Machine Design	6d-1 2	Mr. Morse	6	12
Juniors	Machine Design	6d-3 4	Mr. Morse	6	16
Juniors and Seniors	Freehand and Mechanical	2c	Prof. Newman	10	15
Seniors	Mechanical	3b	Mr. Messenger	6	7
Seniors	Domestic Art	7-1	Prof. Steward	10	22
Seniors	Domestic Art	7-2	Prof. Newman	10	23
Seniors	Steam Engine Design	8b	Prof. Field	8	24
Total					299

SPRING TERM, 1917.

Class.	Subject.	No.	Teacher.	Hours per w'k each student.	No. students in class.
Freshmen	Descriptive Geometry	5 ab-1	Prof. Steward	3	27
Freshmen	Descriptive Geometry	5 ab-1	Mr. Messenger	6	27
Freshmen	Descriptive Geometry	5 ab-2	Mr. Iddles	9	23
Freshmen	Descriptive Geometry	5 ab-3	Prof. Steward	9	18
Freshmen H. E.	Mechanical	3a-1	Prof. Newman	10	22
Freshmen H. E.	Mechanical	3a-2	Mr. Stewart	10	22
Freshmen H. E.	Mechanical	3a-3	Prof. Newman	10	19
Freshmen H. E.	Mechanical	3a-4	Mr. Stewart	10	22
Freshmen H. E.	Mechanical	3a-5	Mr. Morse	10	21
Freshmen H. E.	Mechanical	3a-6	Mr. Chapin	10	23
Jun. and Sen. H. E.	Freehand	1e	Miss Holt	6	3
Seniors H. E.	Freehand	11-1	Miss Holt	6	26
Seniors H. E.	Freehand	11-2	Mr. Chapin	6	23
Seniors H. E.	Topographical	3e	Mr. Messenger and Mr. Chapin	10	11
Juniors	Steam Engine Design	8a-1 2	Prof. Field	4	15
Juniors	Design Engine	8a-3, 4	Mr. Morse	4	12
Seniors	Machine Design	6e	Prof. Field	6	22
Total					336

REPORT OF THE DEAN OF THE DIVISION OF HOME ECONOMICS.

President F. S. Kedzie, Michigan Agricultural College,
East Lansing, Michigan.

Dear Sir—Permit me to present the following report for the Division of Home Economics for the year 1916-17.

The enrollment for the year exclusive of the Summer School was 357 as against 330 for the year 1915-16. The comparative enrollment by classes was as follows:

	1915-16	1916-17
Graduates	2	2
Seniors	64	55
Juniors	60	61
Sophomores	71	86
Freshmen	120	136
Special	13	17
Total	330	357

The enrollment in the Summer Session was 60 as against an enrollment of 38 for 1915-16.

For the increase in numbers, the house was leased on Albert Avenue which is known as the College Residence, which furnishes dormitory accommodations for twenty and provides for a boarding club of fifty. The College Cottage, which was opened a year ago proved so successful,

that it has been continued. In addition to this, the former president's house has been used as a Practice House for seniors under the direction of the head of the Domestic Science department. Twenty seniors and three teachers have lived in the house each term, and the work of the house has been divided so that practical experience in House Management could be given to each group of students resident in the house. College credit has been given for this practice work. The students who could not be given places in these houses under college control, have occupied three private houses in East Lansing under college supervision.

There have been some changes in the instructional force of the Division: Miss Emma Francis was made instructor for the year in Domestic Science; Miss Ethel Van Wagenen was made instructor in Domestic Science and given charge of the boarding club and general house management of the Practice House; Miss Lisa Osterholm was made instructor in Domestic Art, but at Christmas time found it necessary to give up the work, and was followed by Miss Grace F. Smiley; Miss Clara Hunt has been House Director for the year and Miss Friedrika M. Heyl has had charge of the Woman's Building.

Owing to the unusual conditions existing in the country this year, it has been necessary to make heavy demand upon all the teaching force of the division, and I wish to take this opportunity to express my appreciation of the very generous response which all the members of the staff have given in time, thought and energy, to the calls that have been made upon them, and the cheerfulness with which they have taken on the new work.

The latter part of the year, the work of the division was characterized by the effort which was being made to prepare the girls in the college to meet the demands which were going to come to them to help in the movement for conservation and preservation of food, and to relate the work of the College to the work of the alumnae and the work of all women's organizations, as well as to the needs of the individual women in the town or on the farm, in order that there might be unity in the work of the state whereever it concerned conservation. For this purpose, the work of each course was adapted to the new demand wherever this could be done without, in any way, lowering the standard of work in the course or detracting from the thoroughness of the work. Special courses in canning and drying of fruits and vegetables were held on Saturdays, that the students might have a chance to review this work before being called upon to do it in their communities. June 25 to 29, inclusive, a special week of canning and thrift was conducted by the division, for Home Economics trained women of the state who had had at least two years previous training, of which one hundred and twenty women availed themselves; and a special two day course was conducted July 5 and 6 for women who wished the training in canning who could not meet the requirements for the week's work. As a result of this work, a large number of our students are giving their time to help the women in the state in this conservation movement, and the efficiency and spirit of service which is being shown should, I believe, be a matter of gratification to the College.

The Guest Room in the Woman's Building, which has been furnished by the alumnae, has been a source of great pleasure to the division, as

it has made it possible to entertain college guests, and to offer a hospitality to transient visitors at the College which it could not offer before.

During the year, the students of the division have organized a Girls' Student Council. This Council will concern itself with many and varied interests in the division, and will work with the Mens' Student Council to maintain the traditions and standards of the College and to promote progress. We feel that the organization of this Council will be a great help in developing the life of the division.

Owing to the growth and to the increased specialization in the division, as well as to facilitate the financial management, separate departments of Domestic Science and Domestic Art have been created with separate budgets, the remaining work of the division being carried on under the denomination—Dean's Office and Dormitories. This is in line with the development of the work of the division, and with the hope which we have had that eventually the dormitory life and department life may be made as distinct as possible.

The greatest need which we have in our division at present is the need for a Home Enonomics Building, in which the class work can be carried on apart from the dormitory and social life of the College, as I suggested in my report for last year. Owing to the increase in numbers, it will be necessary for some provision to be made for extra laboratory space for the coming year, but we are hoping that as soon as conditions will permit, the question of a building suitable to the larger needs of the division may again be given consideration.

Respectfully submitted,
GEORGIA LAURA WHITE,
Dean of Division of Home Economics.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEAN OF THE DIVISION OF VETERINARY SCIENCE.

President F. S. Kedzie, Michigan Agricultural College.

Dear Doctor Kedzie—I herewith present a report for the Division of Veterinary Science covering the fiscal year ending June 30, 1917.

Student and Teaching Personnel: The steady, consistent growth in number of students indicated in my report of a year ago is again manifestly encouraging. Records for the year just closed demonstrate that we have given instruction to three hundred and forty-six students, including the elective work in junior and senior agriculture, both first and second year classes of the five months and eight weeks Short Courses in general agriculture and the seventy students registered in the regular full four year Veterinary Course as follows:

Freshmen	20
Sophomores	28
Juniors	13
Seniors	9

In commenting on our increased enrollment of students working for the D. V. M. degree, it is opportune to call attention to the changes that have occurred since my last report both as regards entrance requirements and length of courses in veterinary colleges throughout the United States. I have previously mentioned how the Michigan Agricultural College, alone of all veterinary colleges east of the Mississippi River, has striven to maintain a four year course of instruction upon a preliminary requirement of high school graduation and how this single-handed effort has contributed to the slow but none-the-less gradual increase in our enrollment; a feature, however, that has brought forth a finished product manifesting both ability and efficiency in the competitive field of the veterinary profession. Beginning September last or on announced intention to inaugurate the new order at the opening of the approaching year, all state colleges are or have under contemplation the adoption of the four year course with fifteen high school units entrance requirement. It is certainly gratifying to thus see the realization and stability of our earlier convictions that the time necessary for a balanced veterinary school curriculum without four full college years lacked opportunity for adequate instruction. This universal adoption of a four year standard with courses constantly demanding recognition is, we firmly believe, but a mile-stone to the ultimate establishment of six years of collegiate work for the veterinary degree, as has been the evolutionary progress of the past twenty-five years from only two short years of but six months each.

Another fact of the past year that should not be regarded too lightly is the pronouncement of the United States Department of Agriculture that henceforth veterinarians for eligibility for government employment must have attended at least four full years of veterinary study and so gained their diploma. This plainly bespeaks the early elimination of the private veterinary schools and hence increased responsibilities upon state colleges for furnishing the necessary practitioners to meet the ever increasing demands of animal husbandry.

Several changes in the division personnel developed during the past year: Dr. J. S. McDaniel, responding to a call from his Alma Mater, left us at the close of 1916 to take up veterinary extension work in Missouri. The place thus vacated was filled through the engagement of Dr. James William Benner, graduate of the Veterinary Division, Kansas State Agricultural College, as Assistant Professor of Veterinary Medicine and Pharmacology. Dr. McDaniel had been connected with this institution since 1911 and was an agreeable as well as efficient colleagur.

Dr. J. P. Hutton resigned as Assistant Professor of Surgery and Clinic at the beginning of the new year to accept a commercial position in an adjoining state. His place was ably filled for the remainder of the college year by Dr. J. I. Handley, a graduate of Alabama Polytechnic Institute, Veterinary Department; it is, however, gratifying to note that Dr. Hutton has been prevailed upon to reassume his work at this institution, returning August 1, as Associate Professor of Surgery and Clinic, thus assuming charge of the newly created department added to the organization of the Veterinary division.

As it became essential to supply additional help for Dr. F. W. Chamberlain incidental to work in both gross and microscopic anatomy, Mr. W. S. Robbins, formerly with the Department of Animal Pathology, was

transferred shortly before the close of the fall term. The work accomplished by Mr. Robbins has been especially commendable and painstaking.

Since the establishment of the course in Veterinary Medicine it has been customary to give, once every two years to senior and junior classes combined, a course in Veterinary Jurisprudence. We again were fortunately able to secure Judge Charles B. Collingwood for the past year to deliver a series of lectures touching the more important phases of law as it relates to business, to federal and state livestock sanitation and concerning responsibilities of the veterinarian in his relation to the client and community.

Course of Instruction: The revised schedule of instruction sanctioned by the faculty a year ago, which entirely eliminates elective courses and more adequately correlates the work, was put into operation for freshmen during the past year with exceedingly gratifying results; indeed, a large percentage of the first year students completed the work in a most satisfactory manner. By vote of the faculty, authorizing a few temporary changes in courses to aid adjustment, the entire new schedule for all classes will be adopted beginning with the opening of the next college year.

The military exigency incident to the declaration of war with Germany has created such an unprecedented demand for skilled veterinarians that we have, with the approval of the State Board of Agriculture, arranged to shorten the next fiscal year for our senior students by advancing the date of graduation some two months; this plan will work out without in the least curtailing the regularly scheduled work.

It was our expressed hope in the annual report of one year ago that before long arrangements might be completed making it possible to offer attractive courses to the practitioners of Michigan. It is gratifying to announce that the division is now planning to offer its courses to graduate veterinarians throughout the approaching college year and so permit them to take advantage of recent information relating to the ever increasing responsibilities obligatory upon trained veterinarians. This we trust will be only a beginning which may promptly lead up to an annual weekly conference or some other attractive method permitting Michigan veterinarians to pursue elective work in surgery, parasitic diseases and problems related to sanitation and animal disease.

Two years ago graduate courses were authorized in Veterinary Anatomy and Animal Pathology and I would repeat the suggestion made a year ago—that it might serve to encourage recent graduates to undertake such studies if one or more half or quarter time assistantships were created; this would serve to develop help in teaching and relieve the present corps of instructors.

The class room work of the five instructors engaged in teaching entirely within the division is, under the revised schedule, distributed as follows:

	Fall weekly hours	Winter weekly hours	Spring weekly hours
R. P. Lyman	13	18	9
F. W. Chamberlain	33	22	25
E. T. Hallman	14	48	5
J. W. Benner	14	16	13
J. P. Hutton	20	32	32

We were unable during the past year to put into operation the changes suggested in the last annual report for the elective courses open to students engaged in agricultural pursuits. We are, however, after a year's deliberation as fully pursuaded as before that the elective work now offered to junior and senior agricultural students can be very materially improved upon by giving the student that definite comparative knowledge of the structure and function of the animal body gained through combining laboratory and lecture work; up to this time, unfortunately it has been impossible to provide suitable class room facilities.

On two previous occasions we have suggested the advisability of establishing an extended course affording opportunity for students to simultaneously pursue work for a Bachelor of Science degree in Agriculture and a Doctor's degree in Veterinary Medicine; since our first mention of this plan the idea has been inaugurated in other state institutions, thus rendering it impossible for us to actually pioneer in the move but not presenting any obstacles to prevent this College undertaking to develop such a course. I shall during the next year undertake to offer the proposition to the faculty of the Division of Agriculture for consideration, hoping, if feasible, that a schedule may be worked out and published in the next annual catalog.

Clinic. Each annual report has elaborated to some extent upon the increasing value and scope of the clinic in its relation to veterinary instruction. The past year shows fewer cases under treatment than is usual; but several factors are contributory to this result, more especially the early closing of the college year and the change in manner of entering cases upon the hospital records. It was, on the whole a very satisfactory year from the standpoint of clinical instruction and provided the senior class with valuable practical experience in handling and caring for sick and surgical cases.

A tabulated report of the Medical Clinic from September 27, 1916 to June 1, 1917:

	Horses.	Cattle.	Sheep.	Swine.	Dog.	Cat.	Total cases.
Azoturia	2						
Ascites	1						
Colic, Intestinal	6						
Colic, Gastric	1						
Chorea					1		
Catarrh	2	1			1		
Conjunctivitis	1				2	1	
Eczema	1				4		
Emphysema	1						
Distemper	4				11		
Dermatitis	1	1			1		
Influenza	8						
Fleas					2		
Gastritis	2				2	1	
Gastro-intestinal catarrh	1	1				5	
Goiter		2				1	
Indigestion, acute	3	2		1	3		
Intestinal parasites	3		3	1			
Mange					1		
Navel Ill	1						
Keritits	1	1				1	
Metritis		1					
Laminitis	1						
Lice	1				1		
Nephritis	3				1		
Obesity					2		
Paralysis	1				1		
Paturient paresis		2					
Peritonitis	1	1					
Pneumonia		1			1		
Purpura Hemmorhagica	1						
Pyometra		6					
Septicemia, Hem		1		1			
Stomatitis						1	
Thrush	2						
Tuberculosis		1					
Diarrhea		1					
Total	49	22	3	3	34	10	121

A tabulated report of the Surgical Clinic from September 28, 1916, to June 1, 1917.

	Horses.	Cattle.	Sheep.	Swine.	Dog.	Cat.	Total cases.
Abortion		8					
Abscess	12	5			1	1	
Amp. tail	1					1	
Arthritis	11						
Carpitis	2						
Castration	6	3		8	2	13	
Castration, Ridgling	4						
Cocked ankle	1						
Cystitis	4						
Dentistry	30						
Fistulous tracts	3						
Fistulous withers	5						
Fractures		1			2	1	
Goiter		2					
Hernia	4		1	1			
Laryngeal Hemiplega	1						
Navicular Disease	3						
Navel Ill	2						
Mastitis		2					
Metritis		9					
Obstetrical	2	1					
Pyometra		7					
Ringbone	3						
Sidebone	4						
Spavin	4						
Stringhalt	2						
Open joint, Infectious synovitis	4						
Ovariotomy	1		5		39	5	
Parurient Paresis		3					
Paralysis			1				
Retained placentae		9					
Sesamoiditis	4						
Sterility	4						
Tumors	13	4		2	5		
Trimming tail and ears					18		
Tympanites		1					
Tendinitis	8						
Thorough-pin	1						
Tuberculin test		10					
Wounds, incised	7				2		
Wounds, Lacerated	11	1					
Wounds, contused	4	1			1		
Totals	161	67	7	11	70	21	337

Alumni. Up to this time something over fifty per cent of our graduates have located as general practitioners in Michigan; it is, however, difficult at this writing to estimate the exact number so engaged owing to the unusual restless conditions throughout this country and the fact that a very great proportion of our alumni have volunteered for enlistment in the Veterinary Officers' Reserve Corps of the United States Army. Accepting an appointment from the War Department during the early spring as examiner of applicants for the Reserve Corps, I have had an excellent opportunity to again meet many of our graduates and also obtain a most favorable impression of their state of preparation and efficiency upon veterinary subjects. Unquestionably this army veterinary work will serve to link in closer bond the practitioner and college.

Anti-Hog Cholera Serum. Shortly following the commencement of the fall term of 1916 the manufacture of anti-hog cholera serum was discontinued and distribution limited to the product on hand. Details of the closing up of this work will be included in the report from the Department of Animal Pathology and we have already alluded to the transfer of Mr. Robbins to the Department of Veterinary Anatomy.

Extension and Research Work. Realizing the high annual death toll among Michigan livestock and appreciating that much of the loss is preventable through adequate establishment of cooperative and educational contact between sanitary experts and agriculturists, we have annually and now continue to urge provision for giving members of the Veterinary Division a closer touch with these problems through permission to inaugurate investigation work upon a more extended scale than at present. We have recently offered the facilities of the Departments of Medicine and of Animal Pathology to the College Extension Division, with a view, if possible, of working out control methods against animal parasitism and infectious abortion among cattle; these and other fields of animal disease problems offer abundant opportunity and we ought to be at work to the fullest extent the resources of this institution can afford.

The usual opportunity for extension work through furnishing information by correspondence, examining material sent in by veterinarians, farmers, and the State Live Stock Sanitary Commission, attending the Grange meetings, institutes, taking part in the program of farmers' week schedules, veterinary gatherings, etc., have been a part of our endeavors during the past year and unquestionably offer fields for greater elaboration as soon as we can increase our available teaching and working force.

The American Veterinary Medical Association met in annual convention at Detroit during the last week of August, 1916, and as appeared fitting for such an occasion members of the Veterinary Division faculty took a large part in the work of the committees created for entertaining visiting delegates.

Recommendation. In closing I particularly desire to emphasize our urgent need of a building to accommodate the Departments of Veterinary Anatomy and Animal Pathology. The allied nature of these phases of work make it possible to arrange a dual purpose building providing laboratory facilities for microscopic work in histology, embryology and morbid anatomy, quarters for dissection for both agricultural and vet-

erinary students, preparation rooms, museum and a necrospy laboratory. In our last report we called attention to our present inadequate building equipment for these phases of work and suggested the need could be provided for through an expenditure of less than $50,000. M. A. C. now enjoys an enviable reputation as an institution for training men as skilled veterinarians and if we would continue to measure up with older well housed veterinary institutions, it is imperative this requirement receive consideration at the earliest moment the College resources will warrant.

Respectfully submitted,
RICHARD P. LYMAN,
Dean of the Division of Veterinary Science.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF ANIMAL PATHOLOGY.

President F. S. Kedzie, College.

Dear Mr. President—I herewith submit report of the work of the Department of Animal Pathology for the year ending June 30, 1917.

A record of the undergraduate instruction work given by the department has been reported in the annual report of the Dean of the Division.

In addition to this two graduate students pursued work in Pathology 100 as a minor and one as a major. Unfortunately the latter was given up during the winter term on account of the resignation of Mr. Keck from the College. This was very unfortunate for the department as the problem he had elected was a most vital one to the cattle breeding industry, viz.: (The pathology of the reproductive organs of breeding cattle). It is to be hoped that this phase of the problem may be continued.

Through the kindness of the head of the Bacteriology department and the Director of the Experiment Station it has been the privilege of the writer to make a few trips throughout the state in the interest of abortion and sterility work in cattle. The purpose of his work has been to collect material for bacteriological examination and to outline measures of control to be carried out by the owner of dairy herds, cooperating with their local veterinarian. The importance of this work cannot be over-estimated and it is the regret of the writer that more time is not available. We are advocating stricter measures with regard to hygiene and sanitation and local treatment of the reproductive organs by specially qualified men and hope to present data in the future to show the results of such control measures. I might remark that there is the most pressing need from two sources in this particular work—a greater appreciation on the part of owners of breeding cattle of the importance of hygiene and sanitation in the control of contagious abortion. Second—to get more veterinarians to qualify to render the purely technical services. Few veterinarians have had the training required to administer this kind of treatment and there is a pressing need for instruction among veterinarians of this nature. These facts are

not reflections upon the qualifications of the practicing veterinarians since it should be remembered that the treatment of diseases of the reproductive organs of cattle has been developed within the last two or three years and few veterinarians have had an opportunity to qualify to administer the best services.

It has been the privilege of the writer to act in the capacity of an extension man in animal diseases to a limited extent. During this year we have made the following trips:

September 18-23, 1916. Attended Lenawee County Fair to give exhibit of diseases of animals.

September 25-30, 1916. Attended Hillsdale County Fair for same purpose.

October 13, 1916. Visited farm of Mr. C——, Owosso, to outline plans for control of abortion.

November 3, 1916. Visited farm of Mr. C—— for same purpose as indicated above.

November 8, 1916. Visited Dr. E—— of Howell to demonstrate method of controlling sterility.

November 23, 1916. Attended meeting of Plymouth Agricultural Association, Plymouth, to give talk on "Contagious Diseases of Cattle."

November 24, 1916. Visited Dr. E—— of Howell to demonstrate method of controlling sterility in cattle.

December 14, 1916. Attended meeting of County Veterinarians, Niles, to give talk on abortion and sterility in cattle.

December 15, 1916. Attended meeting of County Veterinarians, Paw Paw, to give talk on abortion and sterility in cattle.

December 16, 1916. Attended meeting of farmers and breeders, Kalamazoo, and gave talk on tuberculosis and abortion in cattle.

December 29, 1916. Visited Ionia State Hospital to outline measures of controlling abortion and sterility.

January 4, 1917. Visited Dr. D——, Ypsilanti, to demonstrate operation for sterility and outline control measures in herd of cattle for abortion.

January 10, 1917. Attended meeting of County Veterinarians, Pontiac, to give talk on abortion and sterility.

January 18, 1917. Attended meeting of Southwestern Michigan Veterinary Medical Association to demonstrate operation for sterility in cattle.

February 2, 1917. Attended meeting of farmers in Newaygo County to demonstrate operation for sterility in cattle.

February 24, 1917. Visited Dr. G——, Adrian, to demonstrate operation for sterility and outline control measures for abortion in a herd of dairy cattle.

February 26, 1917. Accompanied Dr. M——, Lansing, to three dairy farms to investigate causes of sterility.

March 17, 1917. Attended meeting of veterinarians of Wayne, Oakland and Macomb counties to give talk on contagious abortion and sterility.

March 23, 1917. Attended meeting of veterinarians of Kent, Allegan, Muskegon and Ottawa counties to give talk on contagious abortion and sterility.

April 11, 1917. Attended meeting of farmers and veterinarians of

Newaygo County to give talk and demonstration on the control of abortion and sterility.

June 5, 1917. Attended meeting of veterinarians and farmers, Mt. Clemens, to demonstrate operation for sterility.

June 8, 1917. Accompanied County Agent Nash, Branch County, on tour through counties in the interest of abortion and sterility in cattle.

June 15, 1917. Attended meeting of farmers and veterinarians, Coldwater, to give talk on and demonstrate operation for sterility.

It has been our privilege to continue to serve the State Live Stock Sanitary Commission as Animal Pathologist. The greater part of our work for the Commission consists in examining all diseased animal tissues sent it, but occasionally a trip is made to investigate a report of animal disease. During the past year the following trips have been made for the Live Stock Sanitary Commission:

November 19, 1916. Accompanied State Veterinarian Dunphy to Wacousta to investigate reported case of rabies in a horse.

November 20, 1916. Accompanied State Veterinarian Dunphy to Jackson County to investigate disease of cattle.

December 4, 1916. Investigated disease of cattle near Linden.

January 27, 1917. Investigated disease of horses near Saginaw.

February 12, 1917. Investigated disease of cattle near Forest Hill.

March 19, 1917. Investigated disease of calves near Palmyra.

May 15, 1917. Accompanied State Veterinarian Dunphy to investigate disease of cow near Williamston.

May 19, 1917. Investigated disease of cattle near Ithaca.

June 26, 1917. Investigated disease of cattle near Marine City.

Autopsies and examinations of Animal Tissues.

During the past year we have held autopsies on animals as follows:

Horses	5
Cows and calves	13
Hogs	16
Dogs	3
Sheep	2
Chickens	25
Turkey	1
Rabbit	1
Total	66

Among these we have found:

Purpura hemorrhagica, horse	1
Meso-colic abscess from castration, mare	1
Acute interstitial nephritis (colt 2, horse 1)	3
Bilateral lobar pneumonia, calf	3
Acute pulmonary emphysema, calf	1
Caseous pneumonia, calf	1
Acute fibrinous pleurisy and pericarditis, calf	1
Catarrhal enteritis, calf	1

Acute indigestion, calf	11
Peritonitis due to perforation of uterus in pyometra, cow	1
Pyometra and pyaemic arthritis, cow	1
Umbilical infection, calf	1
Sarcoma of uterus with metastasis, cow	1
Hog Cholera	5
Verminous pneumonia, pig	4
Lobar pneumonia, pig	2
Malnutrition, pig	3
Gastro-intestinal intoxication, pig	2
Bilateral lobar pneumonia, dog	1
Rabies, dog	1
Catarrhal pneumonia, dog	1
Septicaemia, sheep	1
Stomach worms, sheep	1
Tuberculosis, chicken	11
Acute parenchymatous hepatitis, chicken	5
Phthiriasis and intestinal parasitism, chicken	11
Ovarian hemorrhage, hen	1
Eversion of oviduct, hen	1
Coccidial white diarrhoea, chick	1
Constipation, chick	2
Infectious entero-hepatitis, turkey	1
Pneumonia, rabbit	1

During the past year we have received specimens from 108 diseased animals sent by farmers and veterinarians for examination. In some of these cases the tissues had undergone such decomposition as a result of improper packing that a diagnosis was not possible. Among these we have recorded the following cases:

Albuminuria and glycosuria, horse	1
Cysticercus tenuicolis, sheep	1
Caseous pneumonia, cow	1
Carcinoma of bladder, mare	1
Carcinoma of uterus, dog	1
Fat necrosis, hog	1
Fibroma of leg, horse	1
Fibro sarcoma, colt	1
Gastritis, pig	1
Hepatic and spleenic tuberculosis, chicken	4
Hemorrhagic septicaemia, cow	3
Hemorrhagic septicaemia, sheep	2
Herpes tonsurans, calf	1
Hog cholera	2
Indurative pneumonia, horse	1
Lobar pneumonia, calf	1
Lobar pneumonia, hog	1
Melano sarcoma, leg of dog	1
Oesophagostoma, Columbiana, sheep	3
Papilloma, horse	1
Parasitic nodules, intestine of pig	1

Polymorphonuclar leucocytosis, horse	1
Pulmonary tuberculosis, pig	1
Rabies, dog	4
Pulmonary tuberculosis, calf	2
Sarcoma of neck, dog	1
Sarcoma of liver, hog	1
Sarcoma of liver, horse	1
Sarcoma, tail of horse	1
Sarcoma, of leg, calf	1
Sarcoma, hog	2
Sarcoma of oviduct, chicken	1
Sarcoma, tail of horse	1
Sclerostoma equinum, horse	1
Stephanurus dentatus in kidney fat, hog	1
Streptococci dermatitis, hog	1
Tubercular lymph gland, cow	4
Tubercular mesenteric gland, hog	1
Thysanosoma actinioides, sheep	1
Verminous pneumonia, pig	1
Verminous pneumonia, calf	1

The manufacture of hog cholera serum was discontinued in the early part of the year just closing, at which time Mr. Robbins, who was in control of hog cholera serum work, was transferred to the Department of Anatomy. However, he has continued to have control of the distribution of hog cholera serum as demanded by purchasers. He and Miss Wood submit the following financial report of the work for the year.

FINANCIAL REPORT ON HOG CHOLERA SERUM PRODUCTION.

Feed, concentrated	$443 56
Hay, straw and roughage	18 94
Swine	283 81
Labor	1,047 00
Apparatus and Sundry items	295 96
Total	$2,089 27
Actual receipts for serum and virus and outstanding accounts	$1,357 30
Receipts for pigs	938 62
Receipts for syringes, needles and ear tags	23 80
Value of tested serum on hand at 1c per c. c.	210 00
Value of untested serum on hand at ½c per c. c.	455 00
	$2,984 72

SERUM.

Total number c. c. tested serum on hand July 1, 1916	203,000
Total number c. c. drawn and mixed during year	44,000
Total	247,000
Total number c. c. sold July 1, 1916 to July 1, 1917	104,091
Total number c. c. used for testing and experimental purposes	5,000
Total number c. c. used on College herd	11,855
Total number c. c. mixed and tested on hand July 1, 1917	21,000
Total number c. c. mixed to be retested	91,000
Total number c. c. lost due to freezing and breakage	14,054
Total	247,000

Respectfully submitted,
E. T. HALLMAN,
Associate Professor of Pathology.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF ANATOMY.

F. S. Kedzie, President, Michigan Agricultural College.

Dear Sir—I herewith make the second annual report for the Department of Anatomy.

The work of the department has been entirely that of teaching. The following self explanatory table is based on thirteen, twelve and eleven week terms, fall, winter and spring respectively.

	No. of students.	Credits.	Lectures.	Laborat'y.	Total.
Fall Term:					
Anatomy 1a	25	4	26	78	104
Anatomy 2a	25	4	13	78	91
Anatomy 3c	18	3	26	39	65
Anatomy 4	12	4	13	117	130
Totals	80	15	78	312	390
Winter Term:					
Anatomy 1b	27	3	12	72	84
Anatomy 2b	20	3	12	72	84
Anatomy 3a	30	4	24	72	96
Totals	77	10	48	216	264
Spring Term:					
Anatomy 1c	15	4	11	99	110
Anatomy 2c	25	3	11	66	77
Anatomy 3b	27	4	22	66	88
Totals	67	11	44	231	275
Anatomy 103	1	4	....	132	132
Grand total	225	40	170	891	1,061

Since the spring term was of only six weeks duration it has reduced the total hours for the same from 275 to 150 hours and the grand total from 1061 to 936 hours.

During the year three illustrated lectures on poultry subjects were given by myself, two at the Poultry Roundup and the other one at a meeting of the Veterinary Association of Comparative Medicine.

I received from Dr. S. Sission, Chairman of the Committee of the American Veterinary Medical Association, on the Revision of Anatomical nomenclature, an invitation to participate in its work which would be of mutual benefit to this institution and to myself, but the heavy teaching work of the department made it impossible to accept the same.

During the fall term help for the Department of Anatomy was asked for and Mr. Robbins was transferred to it and while his activities were limited because of his little training in anatomy, he has nevertheless rendered valuable assistance in the preparation of material for dissection and laboratory work. I regret his dismissal.

The above clearly shows the need of additional help in the teaching of anatomy and is indigent to its development and attainment. The need of a full time assistant is real.

In the 1916 report for this department mention was made of the inadequate and unsuitable room allotted to anatomical work and to the development of a museum of anatomical material. That condition still obtains. Need for a building to house the anatomy and pathology work of this institution is urgent and warrantable, a structure similar to the two story engineering shop but having three floors at a cost of about $35,000, would repay many times its cost to the state.

Yours truly,
FRANK W. CHAMBERLAIN,
Associate Professor of Anatomy.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF BACTERIOLOGY AND HYGIENE.

President F. S. Kedzie.

Dear Sir—The most notable event in the work of this department during the school year has been in connection with our relations to the Division of Home Economics. Extensive alterations have been made in the students' laboratory for the accommodation of about one hundred additional women students in our first laboratory course in bacteriology. We are so impressed with the results of the five credit lecture course for women in place of the two credit courses throughout the year that we strongly advise that men students substitute a similar five credit, one term course for the two credit courses extending throughout the year. This would be in the interest of economy and efficiency.

Assistant Professor Northrup reports on the laboratory instruction as follows:

"The instructional work under my immediate supervision comprising courses 2, 3, 4, 11 and 23 was carried on by Mr. W. L. Kulp and myself during the summer and fall terms. At the end of the fall term Mr. Kulp resigned, and Mr. F. W. Fabian took his place, assuming his duties the first of January. Although the winter term presented the hardest work and the most problems to solve, Mr. Fabian proved himself capable of meeting the various situations, and successfully instructed in courses 2 and 4.

"This winter term marks the first required laboratory course in bacteriology in the Home Economics course since the year 1904-05 and its institution placed before us certain problems most of which were due to lack of room and equipment, or to an inability to utilize to advantage that which is furnished, either from poor arrangement or poor quality of material. With the institution of this new course it will be mandatory to have new laboratories and additional instructors soon if the tabulated increase in enrollment in the Home Economics Division continues proportionately. It is unfortunate that Course 2

is required of the junior veterinary students also in the winter term, since students who wish to elect Course 2 or advanced courses in bacteriological laboratory work may not do so on account of lack of desks and equipment. This condition was serious enough this past winter term to affect the enrollment in all courses; with some students it will mean failure to enroll at any future term. Effort should be made to meet this situation at a not too far distant date.

"The work done this spring term proved very unsatisfactory on account of the shortened term. Many students electing laboratory courses in this department expressed their regret at not being able to take all of the work outlined in the term's program. Probably due to existing conditions other students failed to do their best.

"During the spring term, I have had a graduate student in Course 106, Plant Bacteriology, under my supervision. Although not accomplishing a great deal, many interesting points were brought out in the special problem."

I can commend the work of Miss Northrup and Mr. Fabian very highly and can assure you that they have worked under great difficulties both as regards limitations in material equipment and instructional assistance.

Mr. L. H. Cooledge reports on his teaching work as follows:

"One-third of my time during the past year has been given to teaching. During the eight weeks short course I gave daily lectures to twenty-five dairy short course students.

"Course 17, Dairy Hygiene, was given during the winter term to twelve senior veterinary students. We were greatly handicapped in this course for lack of laboratory room.

"In the spring term I gave the laboratory work in the Course Dairy 4, to thirty-four senior dairy students. Lack of laboratory room made it necessary to give this work in the Dairy Building.

"During the fall and winter terms I had two graduate students and during the spring term one. Mr. L. R. Jones has been working on, "A Study of Many Strains of Streptococci with Special Reference to the Streptoccoci Isolated from Cases of Bovine Mastitis," and Miss May Person has made considerable progress on a project entitled "The Care of Milk in the Home."

It would seem advisable to make different arrangements relative to the part played by this department in the teaching of Dairy 4, Market Milk. The preparation of the students taking this course so far as bacteriology is concerned is so diverse that it is almost impossible to outline a course satisfactory to all. Mr. Cooledge is each year proving his ability as a teacher.

Mr. C. W. Brown has had charge of two post graduate students working respectively in Fermentation Bacteriology on, "A Study of Food Fermentations Including the Fermentation of Sauerkraut and the Spoilage of Canned Foods;" and in Dairy Bacteriology on, "A Bacteriological Study of Buttermaking from Gathered Cream."

Under the direction of Mr. I. F. Huddleson there have been two men taking post graduate work on phases of the bacteriology of the reproductive organs of cattle.

Mr. Manuel Justo, one of these men, came to us from Porto Rico. He has submitted a very excellent thesis on, "The Comparative Study

Between the Normal Bacterial Flora of the Udder and that of the Genital Organs of the Cow."

Dr. H. J. Stafseth has also had charge of one man in graduate work. Mr. J. A. Barry has done very acceptable work summed up in a thesis entitled, "Studies of Bacillary White Diarrhea of the Domesticated Fowl."

It is quite clear to me that the relationship borne by our research men to the students taking graduate work is of mutual benefit to the parties concerned. It also helps to furnish a valuable connecting link between the College and the Experiment Station. Many writers and speakers express the conviction that in a university there must be research, but in a college its absence is not fatal. We are not under the necessity of considering this question in the abstract; for us it is settled by the presence of our Experiment Station and our Graduate School. We consider it fortunate for the undergraduates and for the teaching force. The spirit of our research men must be commended highly, for their attitude toward the graduate, and even undergraduate, students leaves nothing to be desired.

Mr. Stafseth has also taken charge of the Pathogenic Bacteriology (Bact'y 19) required of veterinary students but also elected by students in Agriculture and Home Economics and by Graduate students. His success in this work has resulted in his appointment on the regular staff for next year.

For the year 1916-17 the following number of students have been enrolled in this department:

Number of course.	Summer, 1916.	Fall.	Winter.	Spring.	Total for year.	
1*		105			105	692
1a	5	201			206	
1b	8		182		190	
1c	7			184	191	
2	6	41	93	37		177
3	6	10	18	16		50
4	3	9	8	13		33
13	5	75				80
14				40		40
17			12			12
19			15			15
23			3			3
103	2	1	1			4
104		1	1			2
105	3	5	7	2		17
106	1			1		2
Dairy 4, (Market Milk)				34		34
Totals	46	448	340	327		1,161

*Course 1 a five credit subject given in the fall and summer terms is comprised of five lecture or recitation hours a week and is required of sophomores in the Home Economics course. It is a combination of courses 1a, 1b and 1c and was introduced as a prerequisite to Course 2 for sophomore Home Economics students.

The following is an itemized list of the number of cases cared for in and the expense of conducting the Detention Hospitals for the year ending June 30, 1917, exclusive of cases in the General Hospital, no reports of which are received:

Cases	*No.*
Scarlet Fever	33
Mumps	10
Tonsilitis	4
Diphtheria	2
Small pox	2
Chicken pox	1
Nephritis	1
Rheumatism	1
Quarantine (No charge)	17
Total	71

EXPENSES.

Dr. Bruegel	$ 343.50
Nurses	1,839.86
Groceries	715.76
Supplies	308.43
Total	$3,307.55

Our hospital system as well as our general method of supervising student health is not satisfactory from the standpoint of system. That we manage to blunder through each year without any great disaster hardly excuses our shortcomings. Our system should have in mind not only the restoration of student health but also its preservation; also we should utilize our system for educational purposes. Each student should become so impressed by our method of handling the student body both in health and in disease that, as a matter of habit or second nature, he applies or tries to apply such methods in his work and in the community where he establishes himself. I am sure that, as an educational institution, we are losing a great opportunity to play a big part in the physical redemption of the race.

Our most urgent needs are: The physical and medical examination of all students at stated intervals, a full time medical adviser, a capable head nurse for our hospitals, and a General Hospital costing from $10,000 to $20,000.

Our success in handling the outbreaks of infectious diseases this year are due in large part to the activities of Dr. Oscar Bruegel. Mr. Penner and Mr. Lutz have assisted greatly. We are all very grateful to you for your assistance and hearty cooperation in all the activities of the department during the year.

Respectfully yours,
WARD GILTNER,
Professor of Bacteriology and Hygiene.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF BOTANY.

President F. S. Kedzie, College.

Dear Sir—I have the honor of submitting to you herewith the report for the Department of Botany for the fiscal year ending June 30, 1917.

The teaching force has been nearly the same as for the preceding year, viz.: Ernst A. Bessey, Ph. D., Professor; Richard deZeeuw, Ph. D., Associate Professor; Henry T. Darlington, M. S., Assistant Professor; Miss Rose M. Taylor, M. A., Miss Bertha E. Thompon, M. A., Edward F. Woodcock, Ph. D., Harry C. Young, M. S., Instructors; Paul C. Kitchin, B. S., and Walter K. Makemson, B. S., Graduate Assistants. In addition to these George H. Coons, Ph. D., Research Associate in Plant Pathology, and Rufus P. Hibbard, Ph. D., Research Associate in Plant Physiology, in the Experiment Station have devoted about two-fifths of their time to teaching their respective subjects in this department.

We have lost the services of the following: George R. Johnstone, Instructor in Botany, who resigned at the close of last summer to go to the University of Chicago to pursue his graduate studies further. He leaves a very good record for efficient and willing service during the three years he was with us. Mancel T. Munn, Graduate Assistant, completed his graduate work last summer and returned at the beginning of September to his old position as Assistant Botanist at the New York (Geneva) Agricultural Experiment Station. I take opportunity here to express my appreciation of his faithful and efficient services during the year he was back with us. Mr. Johnstone was succeeded by Mr. Young and Mr. Munn by Mr. Makemson.

Thanks to the leave of absence given her by the Board of Agriculture and to competent medical attendance Miss Thompson had so completely recovered her health that she was able to conduct her work this past year with all her old zeal and efficiency.

The number of students taking botany showed a considerable falling off in comparison with the attendance for the preceding year. This falling off occurred in the number of freshmen agricultural students and was due to the smaller freshmen class this past year. Except for a very slight drop in the fall term the number of students taking the elective courses in advanced botany shows a considerable increase. The figures for the past year are as follows:

Summer Term, 1916	24
Fall Term, 1916—Freshmen Botany	234
Other undergraduate courses	151
Postgraduate (major)	5
Short Course	60
	450

Winter Term, 1917—	
Freshmen Botany	221
Other undergraduate courses	103
Postgraduate (major)	5
Short Course	15
	344
Spring Term, 1917—	
Freshmen Botany	188
Other undergraduate courses	57
Postgraduate	3
	248

Where in the same subject a student takes his lectures and laboratory work under different instructors or in different sections he is counted but once in the foregoing tables.

Failing to obtain any action on my recommendation made every year now for the last five years that the roof of the Botany Building be raised so as to make a complete third floor, thus adding about thirty per cent to the available laboratory space in the building, it became necessary to make over the northeast basement room of the old part of the building for a laboratory to be used by advanced students. This room has many disadvantages, in particular the fact that the windows are so small and high up in the wall that the light is poor and artificial illumination has to be used all the time.

The southeast basement room of the older part of the building has been opened through to the newer part of the building as well, and fitted up for a stockroom for glassware and chemicals. Although not as light or convenient as could be desired it is however, a great advance over previous conditions.

In pursuance of the policy inaugurated by the Board and carried out in naming the buildings on the campus it seems to me that no finer tribute could be paid to my predecessor than to give his name to the Botany Building, perhaps calling it the Beal Botanical Laboratory. Dr. Beal has devoted the best part of a long, useful life to the interests of this College and has gained nation and world wide recognition in certain lines of botany and would surely appreciate such a tribute given him while still living, far more than all the praises that might be expressed at the occasion of his funeral.

As far as the limited funds and time available admitted work has been pushed on the Flora of Michigan. In this work Assistant Professor Darlington has carried on the greater part of the studies. In company with him I made another collecting trip down the whole Muskegon River valley in August, 1916. We started at Higgins Lake, stopping for three days at the State Forest where we were the guests of Mr. Marcus Schaaf, to whose hospitality was due the opportunity to make some very valuable collections. From there we went to Michelson, Houghton Lake, McBain, Temple, Farwell, Evart, Hersey, Big Rapids, Newaygo, where we visited Hess Lake, Fremont and Muskegon. At Fremont we were assisted very materially by Keats Vining, teacher of botany in Fremont high school, who piloted us among the chain of

lakes lying northeast of the city. During the trip nearly 1,100 numbers were collected and many important data obtained as to the limits of distribution of many species of plants in that part of the state.

The Herbarium and Botanical Garden have been under the immediate care of Professor Darlington, who has devoted himself to them and has not counted the hours or days necessarily devoted to these time-demanding objects misspent, if he could obtain good results. I quote a few paragraphs from a brief report which he has made to me for the purpose.

"Outside work in connection with the Botanical Garden lasts for about six months or about from April 15 to October 15. This consists of my own labor and the general supervision of additional help. During the latter part of the fall and part of the winter, I spent a large part of four months in organizing the beds and preparing planting plans for the spring. During September I visited the following botanical gardens in the East with a view to getting new ideas: Botanical Garden, Washington, D. C.; New York Botanical Garden; Harvard Botanical Garden; Arnold Arboretum; Bartram Botanical Garden, Philadelphia; Botanical Garden, Smith College; and Waugh's Garden, Massachusetts Agricultural College.

"In March I made a detailed report of the needs of the Garden. In this I called attention to the need of more labor, more plants to fill up the vacant spaces and the desirability of having greenhouse space during the spring. Thanks to your cordial support, progress has already been made along some of these lines.

"*Herbarium.* My work in connection with the Herbarium and identification of material occupied a large part of my time during three winter months. Upwards of a thousand specimens were collected during our survey of the Muskegon Valley last summer. A large proportion of these have been labeled and they will form a valuable addition to that part of the Herbarium devoted strictly to the plants of Michigan. This portion of the Herbarium was rearranged and conforms to an index which was prepared, giving the location of each family. Plant distribution records were made under my direction. These cover our state material through all the families up to and including the Cyperaceae."

We have continued to sell at cost the collections of weed seeds and of plant diseases to the various high schools of the state. These have proved to be very helpful to the instructors in botany and agriculture in these schools. The price charged for these sets covers merely the cost of material and of hired labor, not the hours of time put in in planning and supervising the work.

Three more graduate students majoring in botany have received their M. S. degrees. M. T. Munn completed all of his required residence work by September 1, but his other work at the New York Experiment Station prevented the completion of his thesis until May of this year. The title of his thesis was "The Botrytis Neck Rot Disease of Onions." D. A. Seeley and P. C. Kitchin completed their residence work and submitted their theses with the close of the last college year. Their thesis titles were respectively: "The Climate of Michigan in its Relation to Agriculture" and "The Relation between the Structures of some Coniferous Woods and their Penetration by Preservatives." W. K. Makemson has been investigating the Cladosporium disease of tomatoes and will have completed the required residence by September 1. The work of Herdis L.

Lewis on the Blackleg of the Potato and of Raymond Nelson on certain celery diseases was interrupted by their withdrawal to accept positions elsewhere. Mr. Nelson left to become plant pathologist for the Illinois Central Railroad.

The Botanical Seminar has continued to hold its bi-weekly meetings in the Botany Building as in previous years. The membership of this organization is limited to advanced students in botany who must pass a very stiff examination before they are admitted. The Sem. Bot. as it is usually known has proved to be a valuable auxiliary to the teaching and investigational activities of the department. Their annual public address this past year was delivered by Professor L. H. Pennington, of Syracuse University, on "White Pine Blister Rust."

Several members of the departmental staff gave papers before the Michigan Academy of Science at its meeting at the close of March. Dr. G. H. Coons was chairman of the Botanical Section at that meeting.

Respectfully submitted,

ERNST A. BESSEY,

Professor of Botany.

East Lansing, Mich., June 30, 1917.

REPORT ON THE WORK OF THE SEED LABORATORY.

President F. S. Kedzie, College.

Dear Sir—The state seed law is, as you know, administered not by the Michigan Agricultural College but, under the direction of the State Board of Agriculture, by "inspectors, assistants and deputies." Under this provision of the law I was designated by the Board to be in charge of the work and Miss Bertha A. Hollister was appointed seed analyst in immediate charge of the work under my general supervision. Accordingly I am submitting as the main part of my report the report which Miss Hollister has made to me.

May I venture to ask that the request made by Miss Hollister for 500 reprints of this report be granted? We have need to keep the seed dealers of the state informed upon the affairs of the Seed Laboratory.

When the present seed law was passed by the legislature in 1913 it was in many respects the best law of its kind in the country. It embodied many of the principles now contained in the proposed model seed law recommended jointly by the Association of Official Seed Analysts of North America and the Seed Trade Association. I believe that it will be well for seed dealers and others interested in maintaining a high degree of purity of seeds in this state to put themselves in touch with this proposed law and to consider it from all angles, with the idea of having some action taken by the next legislature should it seem desirable at that time. One proposition, especially, that of having germination tests will greatly increase the work of the laboratory should it be made a part of the state law and would necessitate a considerably larger appropriation than is now available under the present law.

Respectfully submitted,

ERNST A. BESSEY,

In Charge, Seed Laboratory.

East Lansing, Mich., June 30, 1917.

Dr. Ernst A. Bessey, East Lansing, Michigan.

Dear Sir—I respectfully submit the following report of the work of the Seed Laboratory for the year ending June 30, 1917. May I suggest that a request be sent in for five hundred separates of this report, so that it may be distributed among those in the state who may be interested.

Yours very truly,
BERTHA A. HOLLISTER,
State Seed Analyst.

REPORT OF THE SEED LABORATORY.

As in previous years the laboratory has made tests of various kinds of field seeds for the farmers and dealers in the state. In addition to the purity tests made, a number of samples were tested for germination and a number were identified.

LABORATORY EQUIPMENT.

At the present time, we have in the laboratory one Vertical Air-Blast Seed Separator, one Binocular Dissecting Microscope, one Seed Mixer and Sampler, one Torsion Balance with weights, three working boards, three triple aplanat magnifiers of six diameters, and two of nine diameters, forceps and glassware necessary for carrying on the work, and a set of file cases which includes a filing case, made to our order, capable of holding six thousand specimens of seeds.

SEED COLLECTION.

At present the seed collection numbers a little over four thousand samples. Seventeen hundred of these came from Henning of Germany. Five hundred were sent out by the United States Department of Agriculture. One hundred were included in the Halsted collection, and a great many have been received from botanical gardens in different parts of the world, such as Bremen, Petrograd, Moscow, Sydney, East Java and Berlin. Occasionally during the year we receive samples from other sources. This year we are indebted to Mr. Edw. E. Evans of West Branch, for authentic samples of several varieties of soy beans, of the varieties well adapted for Michigan. We are also indebted to the Portland Seed Co., of Portland, Oregon, for samples of flower seeds, over a hundred in number, which will be of great help in making identifications. As seeds are sent in for identification, they are added to the collection in all cases where there is not already a sample, or where the sample already in the collection is of foreign origin.

PURITY TESTS.

The samples received are obtained in one of the following ways:

(1) Sent in voluntarily, by farmers and dealers. The majority of samples tested are those sent in voluntarily. The number coming in this year was twelve hundred, approximately the same as last year, about half coming from farmers and the remainder from seed dealers. There is still some misunderstanding on the part of the farmers with regard to the fee of twenty-five cents which is charged for testing each sample, it not being generally known that this is required by the state law.

(2) Collected by inspectors. Owing to the fact that the seed inspection work, for lack of adequate funds, had to be carried on by the fertilizer inspectors, the greater part of whose time was devoted necessarily to the fertilizer work, they were instructed to take samples only where the required labels were lacking, or where the seed even though labeled, appeared suspiciously foul. The number of samples taken was accordingly small, since a large part of the seed offered for sale by the smaller dealers was provided with the proper labels by the wholesaler, and the remainder was largely labelled by the retailers themselves. Furthermore, the time of year in which the fertilizer inspectors were making their rounds, does not coincide with the period when the bulk of seed is on sale. It would seem desirable to have inspectors who could devote their whole time at the proper season, to seed inspection, but with the present limited appropriation this is impracticable.

RESULTS OF PURITY TESTS.

The seed this year seemed to be of much better quality than that of last year, although I still find a great deal of the brown soft seed in red clover so common last year. This does not seem to be a general condition over the country, as inquiry of other seed analysts indicates that they have found very little of it. The Federal authorities have been working on the problem of imported seed and I did not find much this year that seemed to be of foreign origin.

WEED CONTENT OF SAMPLES TESTED FOR PURITY.

The seeds found as contaminations of crop seeds did not show much variation from those of last year, except that a few such as Wild Carrot, are becoming much more common.

The weed seeds most often found in red clover seed are as follows:

Ambrosia elatior—Ragweed. An annual, native to this country. The seed, which is slightly larger than red clover seed, is light brown in color, somewhat pear-shaped, tapering to a point. The surface is ridged, with the ridges terminating in teeth. These may vary in number or be entirely absent. If the outer hull is broken off, on account of handling, it discloses an inner hull, darker brown in color and smooth. When seed is put through a machine it may have this inner hull removed and then will appear light green in color, almost round, with a point at the base. All three forms are found in commercial seed, but only the two latter will be found in cleaned red clover. It is rather hard to clean out. A field badly infested with this weed should be put under three-year rotation of crops, and the land should be thoroughly cultivated or mowed as soon as the crop is removed in the fall. This weed is disliked by cattle either in pasture or hay, as it has a disagreeable taste and odor, and if present in large quantities will taint milk. S179* W216.

Chenopodium album—Lamb's Quarters, or Pigweed. An annual, introduced from Europe. The seed is about the size of alsike clover seed,

*Many of the weeds described in this report have been illustrated as to their seeds in Bulletin 260 entitled "Seeds of Michigan Weeds," while the weeds themselves are illustrated in Bulletin 267, revised edition. Both of these are Michigan Agricultural College, Experiment Station Bulletins. References to these illustrations are indicated by S for the seed bulletin, and W for the weed bulletin, the number following the letter indicating the figure number.

and is circular in outline, and flattened, both sides being more or less convex. The seed is sometimes enclosed by the dried remains of the five sepals of the flower, but these are often absent. The seed is either dark gray or black in color, and is occasionally found with the hull, or part of it, removed. It flowers from the first of June until frost, and is very widely distributed, occurring in most crops. It may be removed from red clover seed by careful screening. S 46 W 48.

Amaranthus retroflexus—Rough Pigweed. Annual, introduced from tropical America. The seed is highly polished, jet black, or occasionally reddish black, about as large as the seed of Lamb's Quarters. It is almost egg-shaped in outline, much flattened and convex on both sides. It is a very heavy seeder, but may be suppressed by preventing seeding. S 58 W 62.

Chaetochloa viridis—Green Foxtail or Pigeon Grass. An annual, introduced from Europe. The seed is oval in outline, a little pointed at the tip end, with the outer scale folded over the polished edges of the inner scale. It is somewhat smaller than red clover. It is very variable in color, depending on the degree of ripeness. It ranges from yellow through gray and brown to nearly black. When the hull is removed it leaves a light green kernel. It is somewhat lighter in weight than red clover seed, and some of it may be fanned out of red clover. Any practise which will prevent it from seeding will eventually eradicate it. It is one of the commonest weeds in the state. S 24 W 10.

Chaetochloa glauca—Yellow foxtail. The seeds are similar in appearance to green foxtail, but are much larger, and therefore easier to clean out of red clover. S 23 W 11.

Cuscuta spp.—Dodders. This plant is a parasite, mostly pale yellow in color. Many of the varieties were introduced from Europe.

The seeds are dull and vary in color from light brown to very dark brown. They are minutely pitted and are mostly broad oval in shape, a little smaller than red clover, except one or two species which are about the same size. The only thing to be done when an area is infected with this vine, is to cut it out and burn it. The seeds will ripen if the cut plants are left along the roadside or piled in a corner of the field. S 144-8 W 165-0.

Daucus carota—Wild Carrot. A biennial, introduced from Europe. The seed is light green in color, about the size of a red clover seed and oval in shape. It is flat on one side and convex on the other. On the convex side are a number of ridges, some of them terminating in long spines, which are easily rubbed off. This plant is spreading rather rapidly in Michigan. S 138 W 156.

Echinochloa crus-galli—Barnyard Grass. A native annual, found in warm regions. The seeds are similar to those of the pigeon grasses only a little more pointed, and light gray in color and very shiny. They are about the same size as those of yellow foxtail. Not of great consequence except where there is considerable moisture. S 13 W 12.

Panicum capillare—Witch Grass. A native annual. The seeds are elliptical, gray in color and very highly polished. They are much smaller than those of red clover and should be easily cleaned out by fanning. S 17 W 18.

Plantago lanceolata—Buckhorn, Red Ripple, Rib-grass, Narrow leaved Plantain. Naturalized from Europe. Either biennial or perennial.

The seeds are about the same length as red clover seeds, and a little narrower, resembling a canoe in appearance, with both ends rounded. They are brown in color and very shiny. It is very hard to separate the seeds of this weed from those of red clover. There are several machines on the market for this purpose, but in most cases a considerable portion of the red clover is sacrificed in the process of cleaning. S 173 W 196.

Plantago rugelii—Rugel's or Black-seeded Plantain. Perennial, native to this country. Seeds irregular in shape, flattened and black. Slightly smaller than red clover seeds. Common in Michigan. S 175 W 197.

Persicaria persicaria—Lady's thumb or Smartweed. Annual, introduced from Europe. Slightly larger than red clover seeds. Seeds ovate, somewhat heart-shaped, pointed at tip end, jet-black, shining. They are usually elliptical in cross-section, but may be three angled. Rather common, but not of itself a serious weed. It does more harm by harboring insects which may do great injury to the crop. The plants should not be allowed to seed. By cutting several times a season for two or three years, it may be eradicated. S 37 W 38.

Rumex crispus—Curled, bitter or Yellow Dock. Perennial, introduced from Europe. Seeds mostly sharply three-angled, reddish-brown, shining. Very common. All seed-bearing plants should be destroyed before cutting the clover. They may be pulled up easily when the ground is soft after a rain. Salt applied to the crown will destroy the root. S 41 W 41.

Syntherisma spp.—Crab Grasses. Annuals, introduced from Europe. Small crab grass seed is somewhat shorter than red clover, brown to black in color after rubbing. The outer scale as long as the seed. S 11 W 24.

Large crab grass is a little longer than red clover seed, and more slender than the seed of the small crab grass. Light to darker green in color. The outer scale only half as long as the seed. S 12 W 25.

Some of the seeds found in red clover also occur in Alsike clover. Among these may be mentioned Pigeon Grass, Lamb's Quarters, Curled Dock, Buckhorn, and Rugel's Plantain. Aside from these, there are a few others which are very common, which do not occur in red clover to any great extent.

Cerastium vulgatum—Mouse-ear Chickweed. Annual or biennial. Introduced from Europe. Seeds ovoid to nearly circular, flattened, covered with tubercles, light reddish-yellow to dark reddish-brown. Seeds very small. Often found in lawns. May easily be screened out of alsike clover. S 63 W 70.

Lepidium spp.—Pepper grasses. Native, annual, and winter annual. Seeds about half the size of red clover seeds. Somewhat egg-shaped, reddish-yellow to reddish-brown. Flattened, with a groove down the center. Mucilaginous when wet. Heavy seeder. S 92-95* W 100-104.

Medicago lupulina—Black Medick or Yellow Trefoil. Annual, introduced from Europe. Very common in Michigan. Used for forage in Europe, but undesirable as a contaminant of other seeds. Seeds inclosed in a black, oval, strongly veined pod. The seed is greenish yellow in color and somewhat kidney-shaped, with a tubercle near the middle of the concave side. Varies somewhat in size, but usually a little larger than Alsike clover. Matures earlier than Alsike or red clover. S 108 W 119.

*The illustrations Figs. 91 and 92 have been interchanged. Fig. 92 belongs with the description for Apetalous Peppergrass, and Fig. 91 belongs to the description of Field Peppergrass.

Plantago major—Common or Broad-leaved Plantain. Perennial, introduced from Europe. Seeds about the same shape as those of Rugel's plantain, only much smaller, and lighter in color. Can easily be screened out, unless the pods remain whole. S 174 W 198.

Potentilla monspeliensis—Five-finger or Cinquefoil. Annual or biennial, native to this country. Seeds unsymmetrically ovoid, or kidney-shaped, somewhat flattened, nearly white to light brown in color. The surface of the seed is plainly marked with several longitudinal curved ridges. These seeds are very small. S 105 W 116.

Rumex acetosella—Sorrel. Introduced perennial. The seeds are three-angled, brown and very shiny, about the same size as those of alsike clover. Often found with the veined calyx divisions still attached. Occasionally found with the hull removed, when it is still three-angled, but almost white in color. Common on sour soil. The seed is very difficult to remove from alsike clover seed. S 40 W 40.

Silene noctiflora—Night-flowering Catch-fly. Annual and winter annual. Introduced from Europe. The seed is round kidney-shaped, covered with tubercles. It is gray in color and about the size of alsike clover seed. It is very hard to clean out of alsike. The plant is objectionable to live stock, whether as forage or fodder. Its presence in a field is most often due to having sown it in the seed. S 69 W 79.

The only weeds occurring very commonly in Alfalfa are Russian Knapweed, Russian Thistle and Dodder. The seed of the Russian Knapweed is about as large as Alfalfa seed and is white. It was introduced into this country in Alfalfa from Turkestan where it is native. At the latest reports, it has never been known to produce seed in this country. Its presence in Alfalfa indicates imported seed.

Salsola pestifer—Russian Thistle. This is an annual, introduced from Russia. It is not a thistle, but is a tumble-weed, related to Lamb's Quarters. The seed is cone-shaped, with a diameter about equal to that of Alfalfa seed. The covering is transparent, showing the long coiled embryo. It is often found enclosed in the hull, which has a frill at the broad end. Most common in prairie states and not likely to become serious in Michigan, as the conditions are unfavorable to its rapid spread. S 53 W 57.

The weed seeds which are common in Timothy are for the most part the same as those found in Alsike, besides the following:

Cirsium arvense—Canada Thistle. Perennial, native to Europe. The seeds are about the same length as the seeds of red clover, and a little smaller in diameter. They are long, brown and may be slightly curved. The apex is cup-shaped, with a tubercle in the center. It is found quite often in Timothy. The plant reproduces by seeds and rootstocks. As some seeds are not fertile, they will not all germinate. S 191 W 235.

The weed content in a crop depends rather largely upon the locality where grown, and varies considerably, in various parts of the country. By examining the weeds in a sample, it is often possible to determine where it was grown.

GERMINATION.

Although the laboratory is not equipped for germination, I have made these tests when requested to do so. I have been using Petri dishes, with a small piece of blotting paper in each one. This has been a

fairly satisfactory method where only a few samples were being tested but would not be at all practical where a number had to be put through.

Just at present I am carrying on an investigation of the germinators which are on the market. This is being done at the request of the president of the Association of Official Seed Analysts of North America. I have secured, at the present time, three of those manufactured, and hope to have more before the work is finished. The results of this investigation will be reported at the next meeting of the Association.

IDENTIFICATION.

Each year samples of seeds come in for identification. In some cases samples of stock and chicken feeds are sent in, with the request for a list of the varieties of weed seeds present. In some of these were found seeds of Thlaspi arvense, Penny Cress, and Agrostemma githago, Corn Cockle, both of which are injurious to stock. A part of the samples also contained Ergot.

OTHER WORK OF THE LABORATORY.

Aside from the regular work of the laboratory, I tested samples for purity and germination for the referees of the Seed Analysts' Association. In spite of the fact that the germination method was very simple, my results compared very favorably with those from other stations.

I attended the meeting of the Association of Official Seed Analysts in Minneapolis last summer, and the meeting in Detroit this summer. The meeting this year was held a little earlier in the season than formerly, as the American Seed Trade Association was having its meeting in Detroit, and it was felt advisable to have ours at the same time, as many of our problems are also theirs. The meeting this year was very successful.

It is to be hoped this year that the farmers will be very careful of the kind of seed which they save for sowing purposes next season. It is of the utmost importance that the very best seed be saved, because there is apt to be a shortage of seed, and for this reason particularly, good seed is especially desirable. It is also advisable, in view of the fact that labor is becoming scarce, that the seed be cleaned as well as possible, so that no labor be wasted in taking care of the crop.

REPORT OF THE DEPARTMENT OF ENGLISH AND MODERN LANGUAGES.

President Frank S. Kedzie, Michigan Agricultural College,
East Lansing, Michigan.

Dear Sir—I have the honor to submit the following report covering the work of the Department of English and Modern Languages for the year ending June 30, 1917.

The enrollment for the year, exclusive of short courses, was as follows:

	English.	French.	German.	Total.
Summer term, 1916	25	....	....	25
Fall term, 1916	806	103	63	972
Winter term, 1917	839	89	48	976
Spring term, 1917	619	74	31	724
Totals	2,289	266	142	2,697

The teaching staff for the year was as follows:

W. W. Johnston, Professor of English and Modern Languages.
Egbert S. King, Assistant Professor of Public Speaking.
Ernst G. Fischer, Assistant Professor of German.
C. Buren Mitchell, Assistant Professor of Public Speaking.
Norma L. Gilchrist Instructor in English.
Antoinette C. Robson, Instructor in French and German.
Louis B. Mayne, Instructor in English.
Judson Q. Owen, Instructor in English.
Leo C. Hughes, Instructor in French and German.
James B. Hasselman, Instructor in English.
John D. Macmillan, Instructor in English.
Ray B. Weaver, Instructor in English.
Arthur S. Burkett, Instructor in Public Speaking.

Three of those named above, Messrs. Macmillan, Weaver and Burkett, have been members of the department for but one year. The resignations of Assistant Professor Simpson and of Mr. Schneider, which were mentioned in my last report and which became effective September 1, 1916, necessitated some redistribution of the work of the department and the securing of two new men. Accordingly Mr. Macmillan and Mr. Weaver were employed as instructors in English. After my last annual report was submitted to you, Mr. C. C. Armstrong resigned his instructorship in public speaking, and the vacancy was filled by the appointment of Arthur S. Burkett. Mr. Macmillan holds the degree of Bachelor of Arts from Queen's University, Kingston, Canada, and that of Master of Arts from the University of Chicago. He came to us very highly recommended by both of these institutions and by various members of the faculty

of Morningside College, Sioux City, Iowa, in which he was serving for his second year as assistant professor of English. His appointment to his present instructorship was made in May, 1916. Mr. Weaver has the degree of Bachelor of Arts from Carroll College, Waukesha, Wisconsin, and the degree of Master of Arts from the University of Chicago. Members of the faculty of both institutions very strongly supported Mr. Weaver's candidacy for his present position. Mr. Weaver had served for one year as professor of public speaking and instructor in English in the College of Emporia, Emporia, Kansas. He was appointed to his present instructorship in July, 1916. Mr. Burkett is a graduate of Ohio State University with the degrees of Bachelor of Arts and Juris Doctor and has had successful experience in the practice of law. He made an exceptional record in Ohio State University and was unreservedly commended to us by members of the faculty. He was appointed to his present instructorship in August, 1916.

I regret to report that three members of the teaching force given above have resigned. Early in the fall Assistant Professor Fischer announced that the condition of his eyes would necessitate his retiring from teaching for a time at the close of the year. Mr. Owen resigned early in April. Mr. Burkett, who holds a commission as first lieutenant in the Reserve Officers' Training Corps, is now at Fort Sheridan. His position in the college will be held for him, and it is the hope of his colleagues in the department and in the college as a whole that, when his country no longer requires his services in war or in preparation for war, he may return to his work here.

The most important change in our course of study is the addition of one hour a week throughout the year to the work in composition required of freshmen students in agriculture. Heretofore we have had but two hours a week for this very important subject. The change from a two-hour to a three-hour course was made possible by the action of the Departments of Chemistry, of Mathematics, and of Botany, each of these departments generously consenting to sacrifice to the English department one hour for one term. The three hours thus gained will not only add fifty per cent to the classroom work in freshmen English for agricultural students; they should add more than fifty per cent to the students' interest in the subject. The fact that the class has up to the present time met but twice a week has strongly tended to hinder that progressive growth of interest which is essential to good work in any subject. With three hours a week the interest should be cumulative, rather than intermittent, and the results should be manifestly better. In order that no time might be lost in adjusting our plans to the change, members of the department spent many hours during June in thoroughly revising the outline of work for the twelve sections of this class.

Each year it has been a pleasure to include in my annual report the names of students representing the College in intercollegiate debate. This year the question for our tristate debate with Iowa State College and Purdue University, was, Resolved, That the government should provide by fèderal enactment for the compulsory arbitration of all labor disputes involving public utilities, constitutionality conceded. The M. A. C. team which supported the affirmative of this question consisted of H. B. King, B. W. Bellinger, and Howard C. Rather. These

three men met the affirmative team from Purdue University in our college armory on April 20, 1917, and won a unanimous decision. The members of our negative team were E. R. Trangmar, W. G. Retzlaff, and H. E. Hemans. I had the pleasure of accompanying these three young men to Ames, Iowa, and of hearing them win a two-to-one decision over the team from Iowa State College. This is the first time we have won both debates; but of more importance than the winning of decisions is the training which the men are getting, the thinking and speaking ability which they are showing, and the increasing interest in debate manifested by those who attend our debates as well as by those who take part. I am glad to speak here of the intelligent and thorough work of Assistant Professor C. B. Mitchell, to whom it falls to manage these contests and to coach our debaters.

This year we held two freshmen debates—a dual contest with Hillsdale College and a triangular contest with Kalamazoo College and Albion College. In the former we pitted a freshman team against an all-college team from Hillsdale and lost. In the latter, freshmen from M. A. C. met freshmen from the other institutions. We defeated Albion and were defeated by Kalamazoo. The students representing us in these debates were A. J. Mitchell, (Hillsdale), S. M. Powell, (Hillsdale), H. M. Johnson (Hillsdale), E. C. Hach (Hillsdale), J. W. Sims (Hillsdale and Albion), W. E. Fowle (Hillsdale), L. J. Bateman (Kalamazoo), C. J. McLean (Kalamazoo), F. F. Rogers (Albion). Mr. Burkett, instructor in public speaking, did effective work in coaching our students for these debates.

The Eunomian-Holcad contest was won this year by Mr. R. S. Clark, a junior. The winning production, a poem entitled Chores, has been accepted for publication by the American magazine, one of whose editors, Ray Stannard Baker, was a judge of the contest. Mr. Clark has the unusual distinction of having won the Eunomian-Holcad contest twice. Second and third places went to Mr. A. J. Patch, a senior, second place for a poem entitled The Hills, and third place for a poem entitled The Question and Answers. Miss Katherine Hume, a junior, won fourth place with a poem, Barbara, and Miss Ruth Musselman, a sophomore, received fifth prize for a story entitled A Hindu's Choice.

I am much pleased to be able to announce the establishment of the George E. Lawson prize essay contest. This contest was established by a friend and classmate and as a memorial to Mr. Lawson (class 1882), who died February 15, 1916. The annual income from the fund, amounting to $25, will be awarded annually to the male undergraduate student whose essay, submitted in competition for this prize, is adjudged to be the best. Public announcement of this competition was first made in the fall term of 1916, and the contest was first held in the spring term, 1917. The Lawson prize was won by Mr. I. B. McMurtry, a special student in agriculture. His essay was entitled, Education: To or Away From the Farm? I am confident that this annual contest will serve as a stimulus and incentive to many of our students who are interested in writing. As the quality of material submitted in competition for the Eunomian-Holcad prizes has improved steadily from year to year, I believe that we may expect similar results from the George E. Lawson prize. The former contest is for poems and stories, the latter for essays.

Though the Department of English is in no way directly concerned

in the student paper, The Holcad, I wish to mention here, as a matter of record, that a very important change was made last year in the manner of selecting the entire editorial and reportorial staff of the Holcad. The fiscal year of the college paper is from spring vacation to spring vacation. The staff which served from the spring of 1916 to the spring of 1917 worked out a plan for placing the selection of members of future staffs upon a competitive basis, and the students in their annual election approved the change by a very large majority. One feature of the plan is that future editors-in-chief will win their positions only after competition, first as reporters, later as assistant editors, with a considerable number of other aspirants for the place. Any student in the college may compete for a position. The details of this plan are given in The Holcad of March 20, 1917.

In closing I wish to express my appreciation of the very substantial support which the President of the College and the Board of Agriculture have given to my department. The salaries which I was authorized, last spring, to offer for new instructors enabled me to bring in three strong men to fill the places vacated by resignation. The increases granted this year are a decided encouragement to the members of the department, and in many ways other than in increasing salaries the President and the Board have consistently supported the department.

I wish also to refer here to the energy and the ability with which the members of my department have carried on the year's work. I am especially grateful to those who so actively worked upon the revision of several of our courses during the month of June.

Very respectfully submitted,

W. W. JOHNSTON,

Professor of English and Modern Languages.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF MATHEMATICS.

President F. S. Kedzie, College.

Dear Sir—I have the honor to submit for your consideration the following report on the work of the Department of Mathematics for the year ending June 30, 1917:

During the year the teaching staff of the department was as follows:

L. C. Plant, Professor.
M. F. Johnson and L. C. Emmons, Assistant Professors.
S. E. Crowe, R. H. Reece, G. G. Speeker, W. M. Wible, E. C. Kiefer, W. A. Reinert, and Vern James, Instructors.

During the year the members of the staff have not only utilized their spare time in broadening their mathematical knowledge and in correlating their work with that of allied departments, but a number of the members have done graduate work in our best universities. Assistant Professor Emmons spent his year's leave of absence at Harvard Uni-

versity, where he received his master's degree in mathematics in June. Mr. Vern James filled the vacancy caused by the absence of Mr. Emmons. Mr. Reece took advantage of the opportunity granted him to spend the fall term doing graduate work in the University of Wisconsin, and, in exchange, to teach in the summer school without remuneration. Other members of the department are spending their summer vacation period in doing graduate work.

The department believes in the personal relation between instructor and student. For this reason, each instructor supplements class work with conferences with his students. After an experience of three years, the department is convinced that the results obtained through these conferences justifies the large amount of time spent in this way.

I take this opportunity to express to the staff my appreciation for their constant efforts to strengthen their teaching and for the interest they have taken in the mathematics for agricultural students.

The total number of students taking mathematics during the year was 1,183, divided among the different terms as follows: fall, 374; winter, 431; spring, 351; summer, 41. The total number of class periods for the year was 400, divided among the different terms as follows: fall, 110; winter, 130; spring, 100; summer, 60.

Respectfully submitted,
L. C. PLANT,
Professor of Mathematics.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF CHEMISTRY.

President Frank S. Kedzie, College.

Dear Sir—I have the honor to submit the following report on the work of the Department of Chemistry for the year ending June 30, 1917.

We have been especially fortunate in retaining the entire teaching force of last year for the present year. In addition Mr. P. S. Brundage, a graduate of the University of Michigan, has served as an instructor and we have had the services of a senior student assistant for two terms. The teaching staff for the year was as follows:

A. J. Clark, Professor.
R. C. Huston, Associate Professor.
B. E. Hartsuch and W. P. Wood, Assistant Professors.
D. T. Ewing, D. C. Carpenter, H. L. Publow, C. D. Ball, K. G. Hancher, T. E. Friedemann, E. L. Underwood, and P. S. Brundage, Instructors.
R. W. Berridge, Assistant.

The successful work of the department during the past year has been largely due to the excellent spirit of cooperation which has existed among the members of the staff and to the hard, conscientious work of each one.

Five junior engineers elected the newly installed engineering chemistry

group and it is probable that the number of students in this work will increase rapidly.

With from six hundred to eight hundred students taking laboratory work in the department each term, the work is tending to lose efficiency on account of the crowded condition, and an extension of laboratory space will soon be an absolute necessity.

An important accomplishment of the year was the establishment of a local section of the American Chemical Society at the college. Mr. Ewing and Mr. Wood deserve much credit for their efforts in obtaining the cooperation of the other scientific departments on the campus in this project.

Following is a table showing the number of students taking work in the department during the past year:

Number of course.	Summer session.	Fall term.	Winter term.	Spring term.
1a	7	...	137	29
1	9	395	...	...
2	4	...	203	...
3	9	...	...	195
3a	3	...	...	92
4	...	...	83	...
5	...	...	...	33
6	...	...	12	...
7	6	95	...	...
7a	...	6	...	...
7b	...	...	...	6
8	2	...	22	...
9	3	...	...	107
10	6	87	...	...
11	2	...	...	26
12	1	...	108	...
16	...	...	...	11
17	...	...	...	27
18	...	4	7	...
19a	...	6	...	...
19b	...	...	5	...
21	8	...	...	...
21a	...	57	...	...
21b	...	...	51	...
20	...	...	...	6
Graduate	...	3	4	1
Short Course	...	...	50	...
Totals	60	653	682	533

Respectfully submitted,
ARTHUR J. CLARK,
Professor of Chemistry.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF ZOOLOGY AND PHYSIOLOGY.

To the President.

Sir—I have the honor to submit the following report of the Department of Zoology and Physiology for the year ending June 30, 1917:

The work of the department has progressed normally and satisfactorily during the year and there have been no changes in the instructing force, all the members of which have been re-engaged with a single exception. It seems likely that the work can be done next year with one less instructor, owing to the lightening of the fall term by cutting out the elementary zoology from the Home Economics course, and Mr. W. E. Eastman will be released on the expiration of his contract.

Of course other changes may be rendered necessary as a result of the draft for military purposes.

The following tabulation shows the number of instruction hours, number of classes, and number of students assigned to each member of the department during each of the three terms. In addition Professor Conger taught small classes in Elementary Zoology and Physiology during the summer school.

TEACHING WORK OF DEPARTMENT 1916-1917.

	Fall term, 1916.			Winter term, 1917.			Spring term, 1917.			
	Hours per week.	Number of classes.	Number of students.	Hours per week.	Number of classes.	Number of students.	Hours per week.	Number of classes.	Number of students.	Total.
Prof. Walter B. Barrows	11	1	5	10	2	42	12	2	49	....
Asst. Prof. B. B. Roseboom	12	3	65	15	4	58	16	4	58	....
Asst. Prof. F. A. Burt	12	2	29	18	3	32	14	2	21	....
Asst. Prof. A. C. Conger	14	2	45	18	3	88	15	2	64	....
Instr. V. E. LeRoy	18	3	77	21	3	79	18	3	52	....
Instr. W. E. Eastman	15	4	64	19	4	55	15	3	51	....
Instr. J. W. Stack	17	4	76	22	4	52	18	3	67	....
Instr. S. G. Bergquist	18	3	61	21	4	72	16	3	58	....
Totals... Hours	117	......	......	144	......	......	124	......	......	385
Totals... Classes	......	22	......	......	27	......	......	22	......	71
Totals... Students	......	......	422	......	......	478	......	......	420	1320

There is little else to record in connection with the work of the year except that in common with other departments we have suffered somewhat from the lack of funds due to the loss of the Engineering Building. This has not directly affected class work but has limited the work planned in connection with loan collections of birds and other specimens which we had hoped to prepare for extension work. In several instances we have sent out collections of fifty to one hundred mounted specimens for exhibition in connection with special meetings of nature clubs,

women's clubs and school exhibitions, but the amount of material available has been small since it does not seem wise to use the first class specimens from the museum for such purposes. Several members of the department are available for nature study talks in connection with this extension work if a little notice in advance can be given.

GENERAL MUSEUM.

The condition of the general museum remains almost precisely as last year. Lack of funds has prevented the relabeling of specimens, and lack of expert labor has prevented the transfer of specimens to proper perches or standards for exhibition and the preparation of duplicate specimens for loan collections. The museum, as always, has proved one of the most popular points of interest for visitors to the College and its collections are used with increasing frequency by our own students. There is almost no limit to the development of such usefulness if a moderate amount of money and a little expert labor can be provided. The museum should be the largest and best natural history museum in the state and its location and present size and condition fully warrant its being considered the State Museum. I trust the time is not far distant when its tremendous importance as an educational factor may warrant the provision of a modern museum building in which the collections can be properly displayed and the aim of a first class state museum fully realized.

Respectfully submitted,
WALTER B. BARROWS,
Professor of Zoology and Physiology
and Curator of General Museum.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF ENTOMOLOGY.

President F. S. Kedzie.

Dear Sir—Following is a brief report of the Department of Entomology for the year ending June 30, 1917.

During the year just ended several changes have been made in the courses of instruction dealing with the Department of Home Economics. Course VI, a required course, dealing with household insects, has been dropped, and an elective consisting of a year's work in Entomology has been substituted. This latter course was not given during the past year because the number of students registering in it hardly seemed to warrant the expense of carrying a five credit course through the entire year. Five short courses were given during the fall and winter—two in Apiculture and three in Entomology. During the summer school of 1916, Entomology 1 was given by Miss Eugenia McDaniel.

On September 1st Mr. G. C. Woodin resigned, to pursue advanced work at the Ohio State University. Mr. P. B. Wiltberger, a graduate of Ohio State University and later instructor in the University of Maine,

was appointed in his place, reporting for duty on April 1st. Mr. Wiltberger is employed both by the College and by the Experiment Station, his time being equally divided between the two.

Mr. F. E. Millen resigned at Christmas time to take up a position as instructor in the Iowa State University—his work as instructor in beekeeping and State Inspector of Apiaries being taken up by Mr. B. F. Kindig, who had been for years Assistant State Entomologist of Indiana, where he has had extensive experience in beekeeping and in the inspection of apiaries. Fortunately, the last legislature passed a law increasing the direct appropriation for the inspection of apiaries by $1,500.00 per annum. Besides this the legislature conferred on the State Board of Agriculture authority to appoint deputy inspectors, two of which have been temporarily appointed. They are Mr. Paul W. Erbaugh and Mr. Donald P. Barrett. Mr. Kindig's report as State Inspector of Apiaries is to be found elsewhere in this volume. The College now owns a well ordered apiary of twenty-three colonies for use in demonstrations and in class work in the new four term option in Apiculture, which is scheduled to begin with the spring term of 1918.

During the early autumn Doctor G. D. Shafer tendered his resignation, to take effect on September 1, 1917. Doctor Shafer has been Secretary of the Committee on Graduate Work since its present organization, and his loss will be keenly felt both by the student body and by his associates. Doctor Shafer plans to go into private work for a time at least.

During the year the department has made an effort to build up the material used for educational displays in the class room and at gatherings of farmers, fruit growers, and others interested in agriculture.

The calls for extension work are increasing in number and in importance yearly. At present Mr. Don B. Whelan is employed as Extension Specialist in Entomology during the summer and fall, and by the College during the winter and spring. It would appear that the Extension Specialist could well be employed in the field during the entire year.

Respectfully submitted,

R. H. PETTIT,

Professor of Entomology.

East Lansing, Mich., June 30, 1917.

REPORT OF THE STATE INSPECTOR OF APIARIES.

To the Honorable The State Board of Agriculture:

Following is the fourth annual report of the State Inspector of Apiaries for the fiscal year ending June 30, 1917:

The work of the last fiscal year was interrupted by the resignation on January 1, 1917, of Mr. F. E. Millen, the former State Inspector of Apiaries. The following summary of the year's work is, therefore, given in two divisions, the 1916 column referring to the work of the first half of the fiscal year, and the 1917 column referring to the work of the last half of the fiscal year.

	1916	1917
Number of apiaries visited	77	208
Number of apiaries in which disease was found	27	101
Number of colonies inspected	844	2302
Number of colonies affected with American F. B.	113	465
Number of colonies affected with European F. B.	85	81
Number of diseased colonies destroyed	1	61
Number of demonstration meetings	No record	3

The following queen-breeders' yards have been inspected and certificates granted:

Jay Cowing, Jenison.
J. H. Haughey, Berrien Springs.
M. H. Hunt, Redford.
E. A. Leffingwell, Allen.
E. E. Mott, Glenwood.

The law passed in 1913 authorizing the appointment of the State Inspector of Apiaries was amended by the last legislature and the appropriation was increased by $1,500.00. This becomes effective July 1, 1917. The appointment of deputy inspectors was also authorized. Two deputies have been secured and they will begin their work early in July. Much more work will be accomplished than under the previous law. The number of requests for inspection has been so large that even with two assistants it will not be possible to answer all calls for help. Foul-brood has become scattered through probably every county in the state in which the production of honey is an industry of any importance. In every county in which more than one apiary has been inspected, disease has been found. An attempt was made last winter to estimate the probable proceeds of the beekeeping industry in Michigan. As nearly as could be ascertained, the annual production of wax and honey amounts in value to about one million dollars. The future of beekeeping depends upon how well foul-brood is controlled.

Respectfully submitted,
B. F. KINDIG,
State Inspector of Apiaries.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF HISTORY.

President F. S. Kedzie, College.

Dear Sir—I hereby present to you the first annual report of the Department of History and Political Science which was created one year ago by the division of the Department of History and Economics.

By the aforesaid division the following subjects were allotted to the new department, three courses in European History, two courses in American History, two courses in Political Science and the instruction in two other courses, Sociology for young women and Public Finance. The latter courses belong to the Department of Economics.

The enrollment in these courses is shown in the following statistics: History 1, 76; History 2, 27; History 2a, 140; History 3 (U.S.), 65; History 4 (U. S.), 77; Political Science, 175; Sociology, 70; Public Finance, 69. Total enrollment for the year 699, distributed as follows:

By terms: Fall, 267; winter, 287; spring, 145.

By classes: Freshmen, 216; sophomores, 70; juniors and seniors, 413.

From these figures it will be seen that 243 students enrolled in European History and 142 in U. S. History. The heavy enrollments in European History may probably be largely attributed to interest in present world conditions, as indeed may the crowding of all the subjects offered in this department. Students are realizing the importance of understanding the potent forces operating in society today. The department is endeavoring to meet this interest by efficient instruction in courses adapted to this end.

By the division of the teaching force Mrs. Hendrick was assigned to this department. The large enrollment in the fall term courses necessitated additional help and resulted in the employment for that term of Miss May Person as instructor in European History. During the winter term similar conditions resulted in Mr. Paul Miller being employed to assist in handling the Political Science.

In accordance with a plan entered into at the request of Miss White, a club among young women to have for its purpose the pursuit of sociological subjects was organized by Mrs. Hendrick. To make this enterprise easier to handle in the winter term, Prof. C. S. Dunford of the Economics Department took a course in Political Science leaving Mrs. Hendrick free to conduct the sociology classes.

In closing this report I would pay recognition to the splendid service of Mrs. Hendrick throughout the year, as well as the very acceptable services of Miss Person and Messrs. Dunford and Miller in their temporary connection with this department.

Respectfully submitted,

E. H. RYDER,

Professor of History.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF ECONOMICS.

To the President:

The following is the report of the Department of Economics for the year 1916-17.

The total number of enrollments in the department for the year numbered 1,042, distributed as follows: By terms: Autumn, 433; Winter, 210; Spring, 371; Summer, 28. By Classes: Graduate 3; Seniors 189; Juniors 291; Sophomores 297; Freshmen, 268.

The total number of hours taught during the year by members of the department equalled 1,249. This was divided among the four sessions as follows: Autumn, 537; Winter, 516; Spring, 336; Summer 60.

A comparison of the statistical statement given above with those of the reports of previous years will show a number of omissions and variations calling for explanations. The large decrease in enrollment in the department, for example, and the decrease in hours taught by members of the department have the same explanation; namely, the division of the department last year into one of History and another of Economics. We no longer teach History or Political Science, and the enrollments in these subjects are therefore not included in this report as was formerly the case. The customary distribution of enrollments and class hours among the various subjects is also omitted from this report and for the same reason already given, namely the division of the department. As noted before, this has left only the subject of Economics, consequently no gain is made by the utilization of the subject classification of former years.

Three new and specialized courses in Economics—Rural Organization, Marketing of Farm Products and Accountancy were given this year and the number of elections in all of them was very gratifying. Two new subjects in economics were also given in the Home Economics division as the result of the adoption of a new curriculum for the division. The increasing applicableness of economic principles to the every day or practical affairs of life is strangely evidenced by the demands made everywhere by the public upon economists to explain these principles. The head of this department, for example, has given upon invitation, no less than fifteen addresses upon different sorts of economic questions in various parts of the state since making his last report. Rural credit has been the subject most frequently spoken upon but High Cost of Living, Rural Cooperation, and the Dependence of War upon Agriculture have also been discussed.

The economic side of agriculture is indeed receiving a great deal of attention from the farmers of the state in many ways at the present time. The forming of cooperative associations for business purposes has never before been so rapid in many regions as during the past year. Usually these associations are for marketing purposes but, whatever the object of their creation, their growing numbers demonstrate clearly that farmers have at last learned a method of acting in unison along the lines of some one or the other of their economic interests. The

activity is one which should be encouraged in every way and it is fortunate not only for the class room study of these associations but also perhaps for the associations themselves that a small appropriation has been assigned this department for the study of these organizations.

In concluding this brief report, the head of the department desires to express his gratitude to his two associates—Assistant Professor Dunford and Intructor Miller—for their unflagging zeal in the interests of the various phases of economics at this College.

Respectfully submitted,
WILBUR O. HEDRICK,
Professor of Economics.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF PHYSICS.

President F. S. Kedzie, College.

Dear Sir—Herewith I submit a brief report of the Department of Physics for the year ending June 30, 1917—my first annual report, as well as the first for the Department of Physics.

On July 1, 1916, the Department of Physics became a separate department by action of the State Board of Agriculture, with an office located on the first floor, and three rooms (laboratories) in the basement of the Forestry Building. Until Thanksgiving last, when Professors Sawyer and Cory of the Department of Electrical Engineering, moved into different quarters; the former into Shop No. 1; the latter to the R. E. Olds Hall of Engineering, the office, as well as the other rooms indicated, were shared with the Department of Electrical Engineering. Professor Sawyer finished the moving of his apparatus during the Christmas vacation, thus leaving the Physics department the use of the rooms previously occupied by the two departments in common. Due to the fact that the entire staff of the Department of Physics shared the same office, department meetings were of daily occurrence.

Last summer the Forestry Reading room, together with the small classroom north of that, were fitted up for our temporary use as a physics lecture room. I wish to take this opportunity to express my appreciation to Professor Chittenden of the Forestry department, for his kindness in sacrificing the rooms we now occupy temporarily in the Forestry Building.

Apparatus of the combined department, saved from the fire, was inventoried at $11,000, of which the Department of Physics received $2,000 worth of the same. This meagre equipment, however has been added to during the year to the extent that the department now has a fair working equipment.

In organizing and planning our work this year we consulted freely with the other related departments thereby trying to correlate the physics work more closely with that of the other departments, and at the same time present the fundamentals.

The following changes, substitutions and additions were made in the scheduled work in physics during the past year:

(a) *Physics 1d*—Two hours laboratory work per week was substituted for a one hour quiz period per week. This has proved a wise change.
(b) *Physics 4c* which has previously dealt with the theory of internal combustion engines, automobiles and farm lighting plants, was changed to a course in Telephonology this year to meet the needs of the forestry "rangers." Several trips were made by the class to nearby exchanges, starting with the simple manual switchboard (e. g., Haslett, Okemos, etc.) and finally making a careful study of the more complex types of switchboards, such as the one at the Bell Telephone Company's Central Station at Lansing. I wish to express my gratitude to the Bell Company for the assistance rendered us.
(c) *Physics 5*, a required five hour course for Freshman Veterinary students, spring term, was added this year at the request of the Dean of Veterinary Science. This necessitated the working out of a special course suited to the needs of medical students—much abridged.

The total enrollment in the Physics department for the year 1916-17, was 889. The tabulation below shows the courses taught, and the number of students enrolled in each. Each course is a five-credit subject, excepting Physics 4a, 4b and 4c which are three-credit subjects.

Summer Term—1916.

Course	*Enrollment*
Physics 1d	6
Physics 2e	9
Physics 4b	6

Fall Term—1916.

Physics 1d	192
Physics 2d	89
Physics 4a	3

Winter Term—1917.

Physics 1e	178
Physics 2e	72
Physics 3d	92
Physics (Short Course)	31

Spring Term—1917.

Physics 2f	73
Physics 3e	89
Physics 4c	17
Physics 4b	21
Physics 5	11

An abridged course consisting of five lecture and quiz periods per week for eight weeks in the fundamentals of non-mathematical physics

was given to thirty-one of the second year Short Course men. This is practically twice the time they have previously given to physics. Through the courtesy of Mr. Lasley, State Distributor for the Domestic Engineering Company, a Delco Farm Lighting Plant was loaned to our department, which has proved to be of considerable interest to the Short Course men, institute attendants and visitors interested in farm lighting outfits.

Aside from his regular teaching, Professor Laycock has been doing the work of "College Photographer" this year. This work, together with the teaching of a course in optics, has been made possible through the courtesy of Prof. Pettit in furnishing us room for this work in the Entomology Building.

The personnel of the Physics Department for the year consisted of the following:

Chapman, C. W., Associate Professor of Physics.
Laycock, W. E., Assistant Professor of Physics.
Snow, O. L., Assistant Professor of Physics.
Melton, W. A., Instructor in Physics (Sept. 1st to Feb. 1st).
Coyle, J. P., Instructor in Physics (Oct. 1st to Sept. 1st).
Stark, S., Instructor in Physics (Feb. 1st to June 1st).

Mr. Melton resigned Feb. 1st to accept a more remunerative position with the Consumers Power Company, Jackson, Mich. Mr. S. Stark, from the University of Chicago, was secured to fill Mr. Melton's place to June 1, 1917. I also regret that Mr. Coyle has accepted an offer from the Chicago schools for the coming year. I especially wish to commend Professors Laycock, Snow and Mr. Coyle for the genuine interest they have taken in the work of the department, and for their efforts to make the year a successful one in every respect.

Very respectfully submitted,
CHAS. W. CHAPMAN,
Acting Head, Department of Physics.

East Lansing, Mich., June 30, 1917.

REPORT OF THE LIBRARIAN.

President F. S. Kedzie.

Dear Sir—I have the honor to present the following report on the Library for the year ending June 30, 1917.

There have been added to the library during the year 622 volumes, of which 205 were purchased, 285 by binding, and 132 by gift.

Of unbound volumes and pamphlets 270 have been received, of which 4 were purchased. The remaining 266 were presented to the library, and acknowleged when received. Individual mention is therefore omitted.

For bound volumes we are indebted as follows:

Bessey, Dr. E. A. 5
California, state reports, 4
Colorado, 1
Connecticut, 9
Clute, R. L., 2
Florida, 2
Freeman's Minn. Diseases of plants, (to Botany Dept.)
Hitchcock's Botany, (to Botany Dept.)
Hinebaugh, Dr. 1
Illinois, 3
Iowa, 5
Kentucky, 3
Loree, L. F. 1
Louisiana, 1
McCool, Dr. M. M. 1
Maine, 1
Minnesota, 2
Massachusetts, 7
Missouri, 1
Michigan, 16
Montana, 2
National Board of Underwriters, 1
Nebraska, 7
New Hampshire, 1
New Jersey, 3
New York, 7
North Carolina, 3
Ohio, 13
Penn. Forestry Dept. 1
Rhode Island, 1
Rosenwald, J. 1
Smithsonian Institution, 1
South Dakota, 2
Strong, A. H. 1
Supt. of Documents, 1
Thompson, S. 1
U. S. Commerce Dept. 1
Vermont, 1
Washington, 1
Yale University, 10.

Financial conditions made it necessary to drop many of the periodicals for which the library had long subscribed, and war conditions rendered it impossible to secure any publication printed in the German language. The usefulness of our reading room has for this season been somewhat limited. The list of periodicals belonging to the Experiment Station remains unchanged except for those in German.

The following is a list of publications received by the library either through the courtesy of publishers, or in exchange for our own publications:

Aerial Age.
Agrl. Gazette of Canada.
Agrl. Gazette N. S. Wales.
Agrl. Jl. of India.
Allegan Gazette.
America.

American Economist.
American Farming.
American Fruit Grower.
American Food Journal.
American Hebrew.
American Hereford Jl.
American Iron and Steel Institute, Bulletin.
American Issue.
American Miller.
American Poultry Advocate.
American Sheepbreeder.
American Swineherd.
American Thresherman.
Anales de Sociedad Centrifica Argentina.
Angora Journal.
Annals of the Missouri Botanical Gardens.
Australasian.
Australian Museum, Records.
Bay City Times. *Daily.*
Belding Banner.
Berkshire World and Cornhill Stockman.
Better Business.
Better Fruit.
Big Four Poultry Jl.
Blue Valley bulletin.
Boletin Agricola Republica de Panama.
Boletin de Agricultura, Sao Paulo.
Brooklyn Botanic Garden, Leaflets.
Bulletin of the G. Rapids Public Library.
Bulletin N. Y. Botanical Gardens.
Bulletin Pan American Union.
Bulletin Boston Museum of Fine Arts.
California Acad. of Science, Proc.
California Home and Farmer.
Canadian Forestry Jl.
Canadian Horticulturist.
Canal Record.
Carlysle Arrow.
Chicago Packer.
Christian Science Jl.
Christian Science Monitor.
Christian Science Sentinel.
Cold.
Commercial Fertilizer.
Commerce Reports.
Congressional Record.
Creighton Chronicle.
Daily Drover's Jl. and Stockman.
Dairy Record.
Dakota Farmer.
Daughters of the Amer. Revolution Magazine.
Dry Farming.
Deming Graphic, N. Mexico.
Detroiter.
Deutsch Amerikanischer Farmer.
Doherty News.
Duroc Bulletin.
Edison Monthly.
Electric Railway Jl.
Electric Traction.
Electrical Trade.
Elgin Dairy Report.
Etude.
Farm and Fireside.
Farm and Home.
Farm and Ranch Review.
Farm Engineering.
Farm Journal.
Farm Life.
Farm Machinery: Farm Power.
Farm, Stock and Home.
Farmer and Breeder.
Farmer's Advocate and Home Magazine.
Farmer's Advocate and Home Journal.
Farmers' Guide.
Farmers' Review.
Feeding Stuffs.
Field.
Field and Farm.
Flour and Feed.
Flying.
Fruit Belt.
Fruit Grower.
Fruitman and Gardener.
Gas Power.
G. Rapids Herald.
Grange Forum.
Guernsey Breeders' Journal.
Hawaiian Forester.
Hoard's Dairyman.
Holcad.
Holstein-Friesian World.

Horse World.
Horseshoer's Journal.
Illinois Agriculturist.
Illuminating Engineer.
Implement Era.
India, Agricultural Publications.
Indian's Friend.
Indicator.
Ingham County News.
International Institute of Agriculture. Bulletin of Agrl. Intelligence and Plant Diseases. Bulletin Econ. and Social Intelligence. Bulletin Agrl. and Commercial Statistics.
Jersey Bulletin.
Japan Society, Bulletin.
Jewish Farmer.
Johns Hopkins Univ. Circulars.
Jl. of Agrl. Research.
Jl. of Agriculture, Victoria.
Jl. of the Amer. Bankers Assn.
Jl. of the Board of Agrl. and Fisheries, London.
Jl. of the College of Agriculture, Tokio.
Jl. of the College of Agriculture, Sapporo.
Jl. of the Dept. of Agriculture, S. Australia.
Jl. of the Western Society of Engineers.
Kansas Farmer.
Lansing State Journal. *daily*.
Lewiston Jl.
Lilly Scientific Bulletin.
Lincoln Freie Presse.
Lister Institute of Preventive Medicine, Trans.
Live Stock Report. (Clay Robinson).
Louisiana Planter.
Manton Weekly Tribune.
Mark Lane Express.
Market Growers' Journal.
Message of the East. (From Jewish Students in College).
M. A. C. Record.
Michigan Farmer.
Michigan Mirror.
Midland Naturalist.
Moderator-Topics.
Modern Gladiolus Grower.
Monthly Bulletin, State Comm'r. of Hort., Cal.
Monthly Crop Report.
Monthly Review, U. S. Labor Bureau.
National Assn. of Corporation Schools, Bulletin.
National Farmer.
National Grange Monthly.
National Stockman and Farmer.
National Weather and Crop Bulletin.
N. Y. Meteorology, Drapers' Hourly Readings.
N. Y. Produce Review.
Nut Grower.
Official Bulletin, U. S.
Official Gazette, U. S. Patent Office.
Ohio Farmer.
Orange Judd Farmer.
Our Dumb Animals.
Pacific Dairy Review.
Park and Cemetery.
Poland China Journal.
Poona Agrl. College, Reprints.
Power Farming.
Practical Farmer.
Practical Husbandry of Maine.
Proc. Amer. Philos. Soc., Phila.
Progressive Herald.
Public Health Reports, U. S. Marine Hospital.
Publicity Magazine.
Reclamation Record.
Reliable Poultry Journal.
Revista Indus. agricola de Tucuman.
Revue Cretienne.
Rhodesia Agrl. Journal.
Rockefeller Institute for Med. Research, Studies.
Rural N. Yorker.
Russia.
Saginaw Daily News.
Salt Lake Herald Republican.
Saturday Evening Post, (Prof. Cox.)
Scientific Monthly.
Sea Power.
Seed World.

Shepherd's Journal.
Smithsonian Institution,
Contributions to U. S. Nat. Herbarium.
Bul. of U. S. National Museum.
Miscel. Collections.
Social Service Review.
Societa Degli Agricoltura Italiana.
Southern Fruit Grower.
Special Crops.
Sugar.
Sunkist Courier.
Tribune Messenger.
United Weeklies.
University of California, Publications,
Agrl. Science.
Zoology.
Up to Date Farming.
Useful Poultry Culture.
Vertical Farming.
Vogue.
Wallace Farmer.
Washington Farmer.
Weather Review.
Weekly News Letter.
West Indian Bulletin.
Western Honey Bee.
White Breeders' Companion.
Williamston Enterprise.
Wilson Bulletin.
Wilson Bulletin. (Oberlin).

The publications of the United States Dept. of Agriculture, and the bulletins of the various state experiment stations, together with the indexes which cover them, are received and filed in the library. We also receive and file the catalogues from the leading educational institutions of the country. These are received in exchange for our own catalogues.

The number of books loaned during the year for home use was 5,426, an average of about 452 per month. No record is kept of the books used in the library.

We desire to express our gratitude to the librarians of the University of Michigan, and the U. S. Dept. of Agriculture for the use of books and periodicals which they have kindly loaned to us.

The library hours have remained unchanged during the year. Our thanks are extended to our assistants for their uniformly efficient service. Our student assistant, Mr. Halsted gave up his work in the spring term, and was succeeded by Mr. H. A. Lyon who has given splendid service, and whom we are pleased to be able to retain for next year.

To the library of the Experiment Station there have been added 337 volumes: 6 by purchase, 155 by gift, and 176 by binding. This library now contains 5,414 volumes. The college library numbers 37,745 volumes. Total in both libraries, 43,159 volumes. This number includes all department books so far as they have been catalogued.

Respectfully submitted,
LINDA E. LANDON,
Librarian.

East Lansing, Mich., June 30, 1917.

REPORT OF THE REGISTRAR.

President F. S. Kedzie, Michigan Agricultural College.

Dear Sir—I have the honor to submit herewith the report of the work of the Registrar's office for the past year.

The enrollment in the different divisions has been as follows:

REGULAR FOUR YEAR COURSES.

Agriculture and Forestry	741	
Engineering	356	
Home Economics	359	
Veterinary Medicine	65	
Total		1,521
Summer School	239	
Graduate Courses	26	
Total		265

SHORT COURSES.

Two Year Course in Agriculture	135	
Eight Weeks Course in Agriculture and Home Economics	171	
Total		306
Total in all courses		2,092
Names repeated		121
Net Total		1,971

ENROLLMENT BY TERMS.

Course.	Summer.	Fall.	Winter.	Spring.
Agriculture and Forestry	96	715	681	614
Engineering	33	361	312	296
Home Economics	49	360	336	326
Veterinary Medicine	10	56	55	54
Graduate	51	21	25	20
Totals	239	1,516	1,409	1,310

ENROLLMENT BY CLASSES.

	Agriculture.	Engineering.	Home Economics.	Forestry.	Veterinary.	Total.
Graduates	23		2	1		26
Seniors	140	69	56	10	9	284
Juniors	161	67	61	9	13	311
Sophomores	162	89	86	7	26	370
Freshmen	223	127	136	1	17	504
Special Students	27	4	20	1		52
Summer S'n, 1916	123	33	60	10	13	239

WITHDRAWALS.

	Fall.	Winter.	Spring.
Voluntary	143	114	....
Scholarship	25	19	16
Discipline	....	1	1

GEOGRAPHICAL DISTRIBUTION OF STUDENTS.

MICHIGAN.

COUNTIES:

Allegan	16	Grand Traverse	12	Midland	5
Alpena	7	Gratiot	9	Missaukee	7
Antrim	7	Hillsdale	23	Monroe	11
Arenac	1	Houghton	15	Montcalm	8
Baraga	1	Huron	9	Muskegon	18
Barry	14	Ingham	221	Newaygo	13
Bay	21	Ionia	15	Oakland	32
Benzie	7	Iosco	11	Oceana	16
Berrien	30	Iron	7	Ogemaw	1
Branch	17	Isabella	6	Osceola	11
Calhoun	34	Jackson	36	Otsego	1
Cass	8	Kalamazoo	29	Ottawa	24
Charlevoix	10	Kalkaska	1	Presque Isle	2
Cheboygan	1	Kent	67	Roscommon	2
Chippewa	5	Lapeer	10	Saginaw	21
Clare	1	Leelanau	5	Sanilac	14
Clinton	15	Lenawee	29	Schoolcraft	4
Crawford	2	Livingston	9	Shiawassee	24
Delta	17	Luce	1	St. Clair	35
Dickinson	13	Macomb	6	St. Joseph	26
Eaton	19	Manistee	5	Tuscola	10
Emmet	8	Marquette	20	Van Buren	26
Genesee	39	Mason	21	Washtenaw	17
Gladwin	1	Mecosta	4	Wayne	81
Gogebic	1	Menominee	6	Wexford	7

OTHER STATES AND COUNTRIES.

Alabama	1	Maine	3	Pennsylvania	23
Arkansas	1	Maryland	1	Philippine Islands	1
Bulgaria	1	Massachusetts	10	Porto Rico	1
California	1	Minnesota	5	Scotland	1
Canada	1	Missouri	3	South Dakota	1
China	1	Natal	1	Tennessee	2
Connecticut	9	New Hampshire	4	Turkey	1
Delaware	2	New Mexico	1	Vermont	5
District of Columbia	4	New York	53	Washington	1
Greece	1	New Jersey	4	West Virginia	2
Illinois	41	North Dakota	1	Wisconsin	4
Indiana	21	Norway	1	Wyoming	2
Kentucky	2	Ohio	56		

DEGREES GRANTED JUNE 1, 1917.

BACHELOR OF SCIENCE.

a, Agriculture; e, Engineering; h, Home Economics; f, Forestry.

Abel, Herbert Victor, a.
Anderson, Charles Daniel, a.
Anderson, Hessel Frank, e.
Anderson, J. Clyde, a.
Anderson, William August, a.
Andrews, Herman Alderson. a.
Armstrong, Adelaide Eugenie, h.
Barnes, G. Lee, a.
Barnett, Clayton Francis, a.
Bartlett, Herbert Charles, e.
Bayer, Abraham Harry, a.
Bayliss, Arthur Ernest, e.
Beckwith, Leslie Morgan, a.
Benson, Edward Byron, a.
Berridge, Russell Ward, a.
Billings, Arthur Witty, e.
Bird, Ford Marshall, a.
Black, Donald Cecil, e.
Blair, David Edward, a.
Blodgett, Lois Lucile, h.
Blumenthal, Harry Harrison, a.
Bregger, John Taylor, a.
Britten, Eva P., h.
Brown, Malcolm Makepeace, a.
Burton, Clare L., a.
Burton, Mead, a.
Butler, George Sherman, a.
Butler, Lou Ella, h.
Cadmus, Roy Lupton, a.
Campbell, Harry Lee, e.
Canfield, Clare J., a.
Canfield, Harold, a.
Carlson, Ernest Fernand, a.
Carpenter, Wayne Ferris, a.
Carson, Anna Elizabeth, h.
Carver, Josephine, h.
Cashin, Raymond Edward, e.
Castle, Emily Lucile, h.
Clark, William John, a.
Clegg, Gilbert, a.

Clemetsen, Harold Arthur, f.
Clyne, Russell Jay, e.
Collins, Glenn Claude, e.
Comb, Alexander Maitland, e.
Cooledge, Victor Renville, e.
Cook, Wesley James, a.
Cornelius, William Harold, e.
Crocker, Emory Stewart, f.
Cromley, Roy Herbert, a.
Crozier, Charles Russell, a.
Culver, Stanley James, a.
Dalby, Alice Louise, h.
Dettling, George Harold, e.
Dicker, Glen George, a
Dietrich, Clarence L., e.
Dorris, Dorothy Margaret, h.
Durfee, Arthur Armson, a.
Dwight, Samuel Harold, a.
Edmonds, Gordon Columbus, a.
Eggert, William Charles, e.
England, Fred, Jr., a.
English, Hazel Pearl, a.
Estes, Howard Robert, a.
Fick, Hilmar Andreas, a.
Flanders, Lester Ellsworth, a.
Foess, Jacob Emanuel John, f.
Force, Mildred Elizabeth, h.
Ford, Austin E., e.
Fox, Harold Nicholas, e.
Frank, Herman George, a.
Fredeen, Nellie Alfrida, h.
Free, Cydna Florence, h.
Frey, Ernest Jacob, a.
Frimodig, Lyman L., a.
Fry, Clements Collard, a.
Fry, Josephine Lois, h.
Galliver, George Frederick, a.
Garthe, Charles Edward, a.
Gifford, Neil Alfred, a.
Gillespie, George Henry, a.
Glidden, Galen McKee, e.
Goltz, Martha Harriet, h.
Gower, Daniel Ellis, a.
Graham, Frank Orrin, e.
Gretton, Louis Hemans, a.
Gumm, Amy Ray, h.
Haines, Albert Wesley, a.
Hales, Bernice Eulalia Juanita, h.
Halladay, Louise Virginia, h.
Halsted, Alfred Theodore, a.
Hancorne, Helen, h.
Hardy, Harold Dyer, a.
Harman, Samuel Willard, a.
Harms, Emma Margaret, h.
Harris, Frank Baker, a.
Hausberr, Frank Ernest, f.
Henning, Ralph Burton, e.
Henshaw, George Joshua, e.
Hilliker, Ella Louise, h.
Himebaugh, Gero Albert, a.
Himes, Floyd B., a.
Hoag, Chauncey Allen, a.
Hobbs, Fred Stephenson, a.
Hodgkins, Philip Miller, f.
Hogue, Donald Barclay, a.
Holtrop, Grace, h.
Hood, Charles Carlisle, a.
Horton, Bernice Mary, h.
Housholder, Burton William, a.
Huebner, Edward Charles, a.
Jakway, Beatrice Harraden, h.
Jasberg, Urho Gustav, a.
Jedele, Lois Corinne, h.
Judson, Haidee Florence, h.
Kean, Roscoe David, e.
Kelham, John Cecil, a.
Kelley, Roy Palmer, e.
Kettunen, Arne Gerald, a.
Kidman, Carl May, a.
Kimmel, Willis Doyle, e.
Kittle, Howard Victor, a.
Klasell, Frances Evelyn, h.
Knowlton, Herbert John, e.
Kyes, Neenah Almeda, h.
LaSalle, Mary, h.
Lauffer, Earl Axford Robert, e.
Lautner, Elsie Anna, h.
Leach, Melvin Arthur, a.
Leavitt, Lloyd Richardson, a.
Lee, Sheldon Beaudry, f.
Lepper, Russell Lloyd, a.
Levin, Louis Frank, e.
Lewis, Leola Irene, h.
Lillie, Dorothy Alice, h.
Lloyd, Budd Will, a.
Long, Dwight Clark, a.
Love, Alden Butler, a.
Love, Francis Bloom, e.
Luther, LaRue Runnells, a.
McClellan, Albert Lovell, e.
McClure, Byron M., f.
McColl, Victor Clark, e.
McKinley, Ruth Rogers, h.
McLean, Harold Parsons, a.
McWilliams, Robert Harold, a.
Macomber, Henry Edmund, e.
Maire, Abraham Lincoln, a.
Manuel, Elmer John, e.
Martin, John D., a.
Marx, Frank William, e.
Mead, Daniel Leo, e.
Mehmedoff, Mehmed Ali, a.
Miller, George Fowler, a.
Moore, Catherine Marjory, h.
Moran, Lucy May, h.
Morgan, Ralph James, a.
Morrison, Janice, h.
Morse, Harlow Alexander, e.
Muir, Alfred Bierly, a.
Nelson, Minton Samuel, e.
Newlon, Guy Adams, a.
Newlon, Wilson Earle, a.
Nichol, Alfred Horley, e.
O'Meara, Percy, a.
Openlander, Frank William, e.
Osgood, Glenn Wereley, e.
Parker, Esther Anna, h.
Patch, A. J., a.
Pate, Edwin Herman, e.
Patterson, Charles, e.
Pennington, Ray Alger, e.
Peppard, David Loser, a.
Perrin, Helen Gertrude, h.
Peterson, Helen Inez, h.
Phelps, Earl Wayne, a.
Pinckney, Edward William, a.
Pino, Austin Lester, a.
Pino, Otto West, a.
Porter, Alton Millett, a.
Povey, Hazel Emily, h.
Powell, Alice May, h.
Pratt, Leon Albert, e.
Prillerman, Delbert McCulloch, a.
Putnam, Henry Nelson, f.
Quick, Glen Winans, e.
Rasbach, James Bellinger, e.
Rather, Howard Christian, a.
Reid, Thomas Hugh, e.
Rice, Roscoe William, a.
Ritchie, Charles, a.
Roberts, James David, Jr., e.
Robinson, Mary Elizabeth, h.
Rossman, Clare Fite, a.
Rouse, Charles Hiram, e.
Ryan, Marguerite Helen, h.
Savage, William Edward, e.
Schaller, Etta Katherine, h.
Scheetz, Clyde Owen Thomas, a.
Schueren, Elsa Theodora, h.
Schumacher, Albert Fred, e.
Seidel, Carl John, a.
Sheehan, Ralph Whitfield, e.
Sheffield, Arthur Robertson, e.
Shelden, Howard Winfield, e.
Sheldon, John Freeman, a.
Smith, Albert Knight, e.
Smith, Howard Galbrath, a.
Smith, Leon Foster, a.
Smith, Lou Orene, h.
Smith, Louise, h.
Smith, Raymond Clinton, e.
Snook, Blanche Louise, h.
Somers, Max Merrill, f.
Sommer, Henry George, e.
Spafard, Frank Sullivan, a.
Stafford, Fred Ward,e.

Starr, Richard Mallory, a.
Stewart, Glen Orland, a.
Stewart, Hoyt Clifford, e.
Stewart, Lowell O., e.
Stough, Charles Russell, e.
Straight, Bertel Waine, a.
Sullivan, Richard Plaisted, a.
Sutherland, Iva Abigail, h.
Tarpinian, Manuel Sahag, a.
Tasker, Lloyd John, a.
Thomas, Glenn Stanton, a.
Thompson, James Harold, a.
Thompson, Paul Edwin, a.
Thompson, William Darius, e.
Tonkonogy, Michael Raymond, a.
Towne, Dorothy, h.
Tradewell, Avery Pixley, e.
Trangmar, Earl Russel, a.
Tussing, Edna Rebecca, h.
Valleau, Esther Eldora, h.
Van Buskirk, William Frank, a.
Verschoor, Leonard Henry, a.
Vevia, Paul James, a.
Walter, Roy David, a.
Warner, Frank Tolles, f.
Washburn, Charles Abram, a.
Waterbury, Hubert Lawrence, e.
Weil, Norman Oliver, a.
Weston, Clarence Earl, a.
Whalen, Frank Joseph, a.
Wilson, Fred McKinley, a.
Wilson, Lyle Moody, a.
Wixson, Harold J., a.
Wolfe, William Frederick, a.
Woodworth, Bernice Jean, h.
Wright, Walter Reside, a.

DOCTOR OF VETERINARY MEDICINE.

Bolton, Ray Blaney
Burgett, Clark Stephen
Coon, Warren Joseph
Keck, William Carl
Kunze, Elmer Frederick
Stafseth, Henrik Joakim
Zeltzer, Joseph Elihu

MASTER OF SCIENCE.

Awotin, Arnold
Drew, Herbert Emory
Godkin, James
Justo, Manuel
Munn, Mancel Thornton
Seeley, Dewey Alsdorf
Sie, William Kia-Shen
VanWormer, Lewis Hunt
Voorhorst, Ray Gordon

MASTER OF AGRICULTURE.

Berridge, Ashley Moses

MECHANICAL ENGINEER.

Iddles, Alfred

MASTER OF HORTICULTURE.

Carmody, John Henry
Fisher, Durward Frederick
Schleussner, Otto William
Truax, Hartley Eugene

MASTER OF FORESTRY.

Hilton, Huber Copeland

HONORARY.

Baker, Ray Stannard, LL. D.
Garfield, Charles William, LL. D.
Burnett, Edgar Albert, D. Sc.
Cordley, Arthur Burton, D. Sc.
Gillett, Clarence Preston, D. Sc.
Smith, Clarence Beaman, D. Sc.

DEGREES GRANTED JUNE 20, 1917.

BACHELOR OF SCIENCE.

Peters, Karl Andrew, a.

MASTER OF SCIENCE.

Berry, James Alexander
Kitchin, Paul Clifford

In addition, the following degrees were granted at the close of the summer session, 1916:

BACHELOR OF SCIENCE.

Gillett, Wallace Heyser, a
Goss, Henry Ahnefeldt, a
Granger, Frank Marshall, e.
Krammin, John Jacob, a
Quinn, James Rowland, e.
Waldo, Russell Huntington, a.

DEGREE GRANTED JANUARY 10, 1917.

MASTER OF SCIENCE.

Huddleson, I. Forest.

SUMMARY OF DEGREES GRANTED DURING THE YEAR 1916-17.

Bachelor of Science:		
Agricultural Course	132	
Engineering Course	65	
Forestry Course	7	
Home Economics Course	52	
		256
Doctor of Veterinary Medicine		7
Master of Science		12
Professional Degrees		7
Honorary Degrees		6
Total		288

STATISTICS OF ENTERING CLASS.

Number enrolled.

Agricultural Course	239
Engineering Course	146
Home Economics Course	157
Veterinary Course	16
Total	558

Preparation and Admission.

Graduates of Accredited High Schools	471
High School credits and Examinations	18
Credits from other Colleges	69
Total	558

CHURCH AFFILIATIONS.

	Members.	Preference.	Total.
Adventist		1	1
Baptist	32	15	47
Catholic	33		33
Christian	7	1	8
Christian Reform		2	2
Christian Science		11	11
Church of Christ	1		1
Church of God	1		1
Congregational	34	37	71
Disciple	1		1
Episcopal	12	3	15
Evangelical	1	1	2
Evangelical Association	1		1
Friends	2		2
Jewish	1		1
Lutheran	18	5	23
Methodist Episcopal	91	75	166
Methodist Protestant		1	1
Presbyterian	54	27	81
Reformed	6	4	10
Swedish Mission		2	2
Union	1		1
Unitarian		1	1
United Brethren	2		2

PARENT'S OCCUPATION.

	Agricultural.	Engineering.	Home Economics.	Veterinary.	Total.
Auditor	2				2
Banker	2		2		4
Blacksmith	2	3	1		6
Beekeeper	1		1		2
Bookkeeper	1		1		2
Carpenter	2	6			8
Clerk	4	4	6		14
Contractor		2	6		8
Dentist	1	1			2
Designer	1	1			2
Druggist		3	2	1	6
Editor			1		1
Engineer	3	2	3	1	9
Farmer	107	37	38	9	190
Foreman	1	3	1		5
Florist	2				2
Housekeeper	18	4	19	1	42
Insurance	3	1	2		6
Laborer, Common	4	4	2		10
Laborer, Skilled	13	7	3		23
Lawyer	1		4		5
Lumberman	3	3	1		7
Machinist	3	2		1	6
Manager		6	4		10
Mail Carrier	1		3		4
Mason	1	1	1		3
Manufacturer	5	3	7		15
Mechanic	1	1	3		5
Merchant	15	15	11		42
Miner	1	2			3
Minister	6	1	3		8
Miscellaneous	1	4	5		10
Nurseryman	2		1		3
Physician	2	1	6		9
Postmaster		1		1	2
Professor	1		1		2
Printer	1	1			2
Real Estate Dealer	5	1	2		8
Retired	5	5	4		14
Sailor	3				3
Salesman	3	2			5
Superintendent	2	1	2		5
Teacher		3	1		4
Undertaker	1		4		5
Veterinarian				2	2
Not stated	19	8	8		35

Respectfully,
ELIDA YAKELEY,
Registrar.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF ATHLETICS AND PHYSICAL CULTURE.

To the President.

Dear Sir—I have the honor to submit the following report of the Department of Athletics and Physical Culture for the year ending June 30, 1917.

It has been the aim of this department to induce as large a number of students as possible to participate in athletic events and training and to take advantage of the classes in physical exercise and contests as arranged by the department. With the idea of benefiting the whole student body we have encouraged intermural games and have had about 500 students engaged in some sport at various times during the year.

A regular gymnasium class was held during the winter months and a number of the students took part in these exercises. We felt again the need for a new Gymnasium as the Armory was entirely inadequate to accommodate the students during the winter and it has been encouraging to realize that next year we will be installed in the building and able to furnish instruction and room for all those who desire physical work.

Teams representing the College in the various competitive sports have acquitted themselves with much credit and we believe the right step was taken in our continuing intercollegiate competition. At the present writing many of the large universities and colleges have decided to resume athletics next fall as it has been shown that our system of competitive athletics not only encourages loyalty, gentlemanly conduct and absolute fairness, but also equips the boys who participate to take their place in times of war as well as in times of peace, for the defense of their country or the normal pursuits of life.

One of our most important athletic events was the Interscholastic Track and Field Meet held here on May 25th and 26th. Thirty high schools from different sections of the state were represented by about 150 athletes and prospective college men. The meet was very successful and we are confident a number of the participants will attend M. A. C., in the near future. The meet has been of infinite value in getting the high school boys of the state acquainted with the College.

The Athletic Association for the past year has been entirely self-supporting and has paid one-half the salary of the football coach, the salary of the baseball coach and of assistant coaches during the football season besides the all-fresh coach and the assistant director for the year.

Athletic training has been given to a large number of students during the past year, but we look forward with much confidence to the strengthening and betterment of this department under the leadership of Mr. Brewer in the new Gymnasium and feel certain the results will amply justify the erection of the new building.

Respectfully submitted,
G. E. GAUTHIER,
Assistant Director.

East Lansing, Mich., June 30, 1917.

STATEMENT OF FUNDS M. A. C. ATHLETIC ASSOCIATION, FISCAL YEAR ENDING JUNE 30, 1917.

		Receipts.	Disbursements.
July 1, 1916.	Balance on hand	$2,249 43	
	Gate receipts	(a)4,236 60	
	Season tickets	216 00	
	Guarantees	(c)8,638 04	(b)$4,923 00
	Student fees	6,953 74	46 16
	Training table	33 55	1,726 90
	Salaries, labor		4,430 00
	Officiating		794 58
	Travel		3,501 81
	Office and general supplies		4,786 97
	Printing		563 40
	Miscellaneous	79 88	793 63
June 30, 1917.	Balance on hand		840 79
	Totals	$22,407 24	$22,407 24

(a)	Football receipts	$3,922 75
(a)	Basketball receipts	149 75
(a)	Baseball receipts	164 10
(b)	Football guarantees	$7,666 54
(b)	Basketball guarantees	811 50
(b)	Baseball guarantees	160 00
(c)	Football guarantees	$2,900 00
(c)	Basketball guarantees	922 00
(c)	Baseball guarantees	1,101 00

A. M. BROWN,
Treasurer.

REPORT OF THE DIRECTOR OF THE SUMMER SESSION.

President F. S. Kedzie, College.

Dear Sir—I hereby submit for consideration such data as I judge may be of interest concerning the Summer Term now in session, including the supplementary conferences—Rural, Boys' and Girls'—held during the period July 5-12.

The following statistics show the composition of our student body for the present term and that of one year ago:

	1916	1917
Total enrollment	239	196
Number of men	156	92
Number of women	83	104
Number of regular students:		
Men	105	75
Women	27	49
Number of rural teachers	15	32
Number of county normal teachers	5	1
Number of new students	62	60
Number of M. A. C. graduates	28	5
Number of other graduates	36	5
Number of candidates for advanced degrees	17	5

NOTE.—The period covered by this report extends into the next fiscal year, however, to make the subject matter timely reading, it has been deemed wise to publish it in the report for the year ending June 30, 1917.

Distribution of students in departments.

1. Regular courses for students enrolled for degrees.

Animal Husbandry	24
Bacteriology	44
Botany	14
Chemistry	53
Dairy Husbandry	10
Domestic Art	11
Domestic Science	8
English	30
Economics	28
Farm Crops	7
History	8
Horticulture	8
Manual Training	5
Mathematics	34
Physics	20
Pol. Science	9
Poultry Husbandry	4

2. Special courses for rural teachers:

Agriculture	5
Community Leadership	17
Domestic Art	8
Domestic Science	4
Special English	11
Gardening	6
General Science (Nature Study)	11
Rural Education	5
Rural Pedagogy	6

These statistics warrant several observations.

1. The enrollment of men has suffered. The loss in attendance is probably attributable to the unsettled conditions of this year.

2. The number of new students is practically equal to that of last year, indicating that we have held our own in outside attendance.

3. The number of rural teachers in attendance is double that of last year.

4. The number of advance students, both from our own college and other institutions has fallen off materially. The demand for trained men in the conservation programs no doubt explains this fact.

5. The students in attendance are widely distributed through the regular courses offered.

6. The rural teachers are scattered through the several courses. The enrollment in Nature Study, Community Leadership and Special English warrants the conclusion that supplementary courses of this type are needed in company with elementary Agriculture and Home Economics.

The above figures show the distribution of the regular college students in the various departments. Of those enrolled, thirty-three are students deficient in one or more subjects who have remained to remove their deficiencies. One hundred and sixty-three students are taking work in which they have never previously enrolled. Of the total number in attendance, six students are completing work for a degree at the end of this session.

The group of thirty-two rural teachers enrolled this year deserves special comment. This number is double the number enrolled last year and represents seventeen different counties of the state. These students are distributed among the various special subjects as the above statistics show, and I find through a questionnaire that they are attracted to this institution by the practical value they hope to get from these courses for use in the schoolroom. This value they are finding, according to their testimony, in every one of these courses. In addition, they are getting an acquaintance with the activities and spirit of this great institution which they are going to carry back with them to their work. This gives the College another avenue of approach to the rural community and an opportunity to help shape the education of boys and girls of these communities whose training has been too much colored by the city-trained minds of the teachers. There is need of a rural-mindedness on the part of teachers, which can be secured at an institution of this kind. Furthermore, such training will contribute its bit to the better appreciation of the work of this institution throughout the state. These persons are bound to become disseminators of information. If we can have the proper vision of this value and the patience to cultivate its possibilities, the Summer Session may become an invaluable feature of our school year for such individuals and for ourselves. This does not mean large numbers, but a sufficient number to effect the standard of rural education.

In connection with this summer's attendance, I wish to acknowledge the debt owed to our extension workers for their service in directing the attention of rural teachers to our summer work. Many have come as a direct result of their efforts.

Following the plan of previous years, the College held a rural conference to which all persons interested in rural problems were invited. In 1915 this conference enrolled twenty-five; in 1916, forty-two; in 1917, two hundred. The program continued for one full week,

The attendants upon these sessions came from widely distributed parts of the state.

Number of counties represented	41
County sending largest number—Ingham and Shiawassee	13 each
Number of church denominations represented	10
Total communities represented	120
Number of women present	30
Y. M. C. A. Secretaries	5
Total attendance	200

The program of this conference dealt with the interests of the rural community, from moral, educational, recreational and industrial points of view. The purpose in mind on the part of the College were improvement of those who serve the various rural communities by rendering

them more intelligent as to rural affairs in the pursuance of their work as well as to increase their enthusiasm for the life and work in the rural community.

The participants in the program were individuals who had achieved in some field which enabled them to speak with confidence and authority. Rarely has any gathering upon this campus been characterized by a greater degree of genuine enthusiasm, and real interest in the subjects presented than has been the case in this gathering. These individuals will return to their homes with an intensified interest in their labors and with a warm place in their hearts for this College whose royal treatment brought forth their emphatic appreciation. Thus has the College had an opportunity to cultivate the friendship of representatives of the rural communities who are in positions to cooperate with the College in its efforts for community betterment. The spirit of this gathering may be judged from the fact that this body asked for a continuance of this conference next summer with a request that the program shall consist partly of courses of study in the various phases of agriculture and home economics through a period of two weeks.

A second annual conference of Boys' and Girls' Club Leaders was held July 9-14 with an attendance of one hundred and fifty-two. Last year this gathering drew one hundred to the campus. The program was designed as a training school for the club leaders of the state, and consisted partly of periods for discussion while other periods were devoted to demonstrations. Like its predecessor of last year, this gathering was full of genuine interest and enthusiasm.

In closing I desire to express my appreciation for the universally splendid spirit of cooperation which has prevailed both on the part of teachers and of pupils.

I believe the efforts of our teachers are bringing forth desirable results in that they are demonstrating beyond question the value of this session by making it clear that there is work well worth while for the College at this period of the year. Two things need to be kept in mind at this time, it seems to me. The present session has suffered in attendance as might have been expected, since it opened at a time of very great stress on account of the war. As a result the expense of the session is proportionately higher, although the total cost is less than that of last year. The terms of the regular year will suffer in the same way but no one will assume to judge the merits of the College by results at such a period. In brief, the factor of very great concern is whether the institution is performing an important service to the commonwealth or not. This should be judged in the light of existing conditions. In the second place, I would note that the work of the summer is of a distinctive character such as is not found elsewhere in any summer school in Michigan. Furthermore, this work being of a different character, the value of it is not appreciated over the state, nor is it an easy matter to acquaint individuals with the peculiar merits of our courses. With the tendencies in education so apparent today, it would seem a reasonable supposition that the opportunities of this type of schooling will be more and more appreciated and that the College will find its Summer Session, as well as its other sessions, of rapidly increasing value.

Respectfully submitted,

E. H. RYDER,

East Lansing, Michigan, June 30, 1917. Director Summer Session.

ANNUAL REPORT OF THE LIBERAL ARTS COUNCIL.

To the President and Members of the State Board of Agriculture:

The Liberal Arts Council has consisted, during the past year, of the following faculty members—

Professor H. J. Eustace.
Professor W. W. Johnston.
Professor W. H. French, Chairman.

Student members—
T. W. Keating.
R. S. Raven.

The Council elected as officers the following:

Chairman and Secretary, W. H. French.
Treasurer, H. J. Eustace.

During the summer and fall of 1916, the Chairman, through considerable correspondence, after careful consultation with President Kedzie and with other members of the Council, secured the following list of entertainments. These entertainments we are pleased to report have been of a high type and we feel sure that they have benefited the student body in many ways:

Oct. 24th.	The Mawson Motion Pictures Concerning the Shackleton Investigations of the Antarctic regions	$100
Jan. 23rd.	Professor Alfred Noyes, visiting Prof. of English at Princeton University	200
Feb. 6th.	Frederick Palmer, European War Correspondent	200
March 6th.	Prof. A. M. Wenley, University of Michigan	50
April 15th.	Musical Entertainment by College Glee Club	150
May 16th.	Minneapolis Symphony Orchestra	382

The last entertainment being given in the Auditorium in Lansing.

The entertainments have all been given in the Armory, except the Symphony Orchestra. The attendance of the student body has been exceptionally good, showing a rapidly growing interest in this type of college instruction. Nine hundred fifty-five (955) students attended the musical entertainment at the Auditorium.

The financial statement appended hereto will show the receipts and expenditures for the year, and the balance remaining in the fund at the close of the year.

Respectfully submitted,
W. H. FRENCH,
Chairman.
H. J. EUSTACE.

RECEIPTS AND DISBURSEMENTS.

Committee on Liberal Arts.
School year 1916-1917.

Receipts:			
June 30, 1916.	Balance on hand	$ 319.28	
June 30, 1917.	Student fees	1,391.26	
Gate receipts		154.25	
Disbursements:			
June 30, 1917.	Refund to students		$ 2.99
	Labor		51.75
	Entertainments		1,160.00
	Printing		14.00
	Miscellaneous		73.30
	Street car expense		63.00
	Balance on hand		499.75
		$1,864.79	$1,864.79

H. J. EUSTACE,
Treasurer.

REPORT OF THE STATE INSPECTOR OF NURSERIES AND ORCHARDS.

To the State Board of Agriculture.

Gentlemen—During the past year, the work carried on by this department has not differed materially from that of previous years. As soon as the season was sufficiently advanced so that we could be reasonably certain there would be little danger of the trees becoming infested previous to being dug in the fall, they were carefully inspected and certificates were granted to all of the nurseries in the state, except a few where the certificates were withheld until the conditions were improved. For the most part, the stock was found to be in excellent condition so far as injurious insects and diseases were concerned. This was especially true of the nurseries proper. The principal difficulty was found upon the premises of a few dealers and growers of small fruit plants who had the previous spring purchased a number of fruit trees and, being unable to dispose of them, had lined them out to grow for another year. During the summer they had become infested with the San Jose scale and in two cases it was found necessary to condemn the entire nursery plantation.

Not only were the trees in the regular nurseries free from the San

Jose scale but the injury from plant lice, wholly aphis and crown-gall was much less than in previous years.

Owing to the fact that comparatively few farmers are putting out apple and peach orchards, several of the largest nurseries in the state have had a surplus of these trees on hand at the end of the shipping season and this has caused a considerable reduction in the acreage so far as fruit trees are concerned. However, they have turned their attention to ornamental trees and shrubs so that the actual acreage is as much, if not larger than it was before. Since such trees and shrubs as the mountain ash, Prunus pissardi, Japan quince, Cornus siberica and others which are quite subject to the attack of the San Jose scale have been very generally dropped from the planting lists, the ornamental nurseries have been quite free from this insect.

ORCHARD INSPECTION.

Under the state law, provision is made for the inspection of orchards by local Boards of Inspectors. In sections where fruit culture is of commercial importance, the townships have made it a practice to appoint inspectors for the purpose and in most cases they have done efficient work. During the year, we have endeavored to secure the appointment of local inspectors in all townships, cities and villages where the conditions seemed to warrant it. Letters were sent to all the supervisors in the counties where the San Jose scale has been troublesome and their attention was called to the requirements under the law. We have been informed that a large number of the inspectors have been appointed. We have been able to aid them by offering suggestions and information regarding their duties.

The members of this department have also responded to many calls from townships where there were no local inspectors or where for various reasons they may have asked for assistance. Particular attention has been paid to the inspection of orchards in counties along the northern limit of the San Jose scale area with the idea of preventing its further spread. We are very glad, indeed, to report that while it has been found in a few cases further north, very little harm has been done north of a line drawn from Ludington to Bay City. There are, of course, many places south of this line where the scale has never appeared and in the southern part of the state, conditions are greatly improved, partly due to the cutting down of old orchards as well as to thorough spraying and the work of insect parasites.

The injury done during the year by peach yellows and little peach, black knot and other diseases, as well as by the canker worm and the other destructive insects, was less serious than in previous years.

EXAMINATIONS OF IMPORTED NURSERY STOCK.

Although the amount of stock imported from Europe during the past year was the smallest since the work of inspection was taken up, the time required was nearly as much owing to delayed shipments which tended to increase the number of inspection trips required. The inspection notices made it very clear that the delays occurred after the stock left New York City and as it was not uncommon to require four weeks for the stock to reach Michigan after leaving New York City, in addition

to the time required in crossing the ocean, it was not strange that much of it arrived in a damaged condition, particularly greenhouse plants which did not arrive until after Christmas. The inspection is particularly necessary to prevent the introduction of the gypsy and brown-tail moths and we are very glad to report that no specimens of either insect were found upon the imported stock.

This department is also furnished by the United States Department of Agriculture with reports of all shipments of nursery stock, timber, stone, etc., from the gypsy moth area in New England and whenever possible we have arranged to examine this stock upon its arrival. The freedom of the shipments from insect pests indicate a very thorough inspection on the part of the state and federal authorities.

WHITE PINE BLISTER RUST.

Reference was made in my last report to this new danger which threatens the Michigan white pine forests and the ornamental plantations. During the year, Congress made an appropriation of $300,000.00 to enable the United States Department of Agriculture to prevent the spread of this disease and to eradicate it wherever possible. The department was also authorized to promulgate such quarantine measures as was deemed necessary for the purpose. A hearing was held in Washington on April 10, 1917, by the Federal Horticultural Board which was attended by representatives from a large number of states as well as by many nurserymen. After thoroughly investigating the matter, the Secretary of Agriculture announced a quarantine which forbade the shipment of white pine and other five-leaved pines, as well as currents and gooseberries, from any state east of the west line of Minnesota, Iowa, Missouri and Arkansas into any state west of that line. Shipments of the five-leaved pines and black currants from New York State and from the New England States into any other state, were placed under quarantine. At the hearing in Washington, it was shown that although the greatest injury has been done in the above states, the disease is found in New Jersey, Pennsylvania, Wisconsin, Minnesota and Ontario. Some years ago it was also found in Ohio and Indiana but the infected trees were destroyed and no trace of the disease has been found for a number of years.

Until the past spring, we had no knowledge of the disease in Michigan. As stated in the report for 1916, all of the nurseries growing white pines and many of the ornamental plantations, were examined during the year by specialists from the United States Department of Agriculture and no trace of the disease was found but it has now been discovered upon four trees in a nursery in the eastern part of the state. These trees were brought from France some eight years ago and from the location of the infection at the base of the trunk, it was very evident that the trees were infected when they were imported. None of the trees in the shipment showed any indications of a secondary infection. The owner has not only destroyed the trees in which the disease was found but all of the other trees in the block to the number of nearly 100. During the last three or four years, something like twenty-five white pines have been sold by this nursery. All of these have been carefully examined without finding trace of the disease. We trust that it will give no further trouble.

In order that every precaution for preventing the spread of the disease in the state might be taken, arrangements were made to cooperate with the United States Department of Agriculture for a thorough survey of all of the nurseries in which white pines are being grown, also of ornamental and forestry plantations of white pines as well as currants and gooseberries, which are the hosts of this disease in two of its stages; the Department of Agriculture agreeing to furnish trained specialists to make the inspection and locate the disease while this department was to take charge of the eradication of infected specimens.

The Bureau of Plant Industry, through its Office of Forest Pathology, placed the work in charge of Dr. L. H. Pennington, of the School of Forestry of Syracuse University, who with eight assistants entered upon the work on May 15th but, with the exception of the white pines referred to above, no trace of the disease has been found in Michigan. The work of inspecting the white pines will be completed by the middle of July, after which the inspection of currants and gooseberries, both native and cultivated, will be taken up.

The following is a list of the Michigan nurseries licensed to grow and sell nursery stock in Michigan, also of the licensed dealers and of the nurseries in other states which have taken out licenses.

LICENSED MICHIGAN NURSERIES FOR 1916-17.

Allen Brothers, Paw Paw.
Asman, C. W., Port Huron.
Babcock & Sons, Geo. M., Charlevoix.
Baldwin, O. A. D., Bridgman.
Bashford, C. L., Mason.
Behnken, J. H., Jerome.
Bigelow, J. N., Bangor.
Bliss, A. W., Harbor Springs.
Boehringer Brothers, Bay City.
Bohl, William, Buchanan.
Bridgman Nursery Co., Bridgman.
Bridgman Nursery Co., The Geo. W., Benton Harbor.
Brooks Co., J. C., Detroit.
Burgess Seed and Plant Co., Galesburg.
Celery City Nurseries, Kalamazoo.
Cole, Levant, Battle Creek.
Collins, Ward E., Fennville.
Coryell Nursery, The, Birmingham.
Cukerski, Wencel L., Grand Rapids.
Curtis & Son, L. T., Flint.
Cutler & Downing, Benton Harbor.
Daly, Thomas W., Watervliet.
Dalzell, B. F., Muir.
Dressel, Gilbert L., Frankfort.
Dunham, Enos W., Baroda.
Elliott H. B., Trenary.
Emlong & Sons, Bridgman.
Ferrand & Sons Co., E., Detroit.
Fetters, Theodore J., Harbor Springs.
Flansburgh & Son, C. N., Jackson.
Freeman, Walter, Otia.
Frissel, Martin, Muskegon.
Gill, Mrs. Bertha M., Ypsilanti.
Glenwood Nurseries, The, Holland.
Greening Nursery Co., Monroe.
Gustin, Chas. F., Adrian.
Hemingway, Geo. R., Ironton.
Hamilton & Sons, A., Bangor.
Hampton, J. E., Bangor.
Hanes, Peter, Farmington.
Havekost, Geo. H., Monroe.
Hawley, Geo. A., Hart.
Hawley, Henry E., South Haven.
Helmer Farm Nursery, Battle Creek.
Hibbler, E. B., Detroit.

Hurlbut-Cross Nurseries, Bangor.
Husted & Co., N. P., Lowell.
Ilgenfritz Sons' Co., I. E., Monroe.
Insulinde Nurseries, Kalamazoo.
Jeffrey, Thomas, Kalamazoo.
Kalle Brothers, South Haven.
Kalamazoo Nurseries, Kalamazoo.
Katzenberger, Valentine, Fosters.
Keith Brothers Nursery, Sawyer.
Kellogg Company, The R. M., Three Rivers.
Kleinhans Floral Co., D., St. Louis.
Knapp, W. F., Monroe.
Knight & Son, David, Sawyer.
Lakeshore Nursery Co., Bridgman.
Lohrman Seed Co., Detroit.
McCormick Nursery Co., Monroe.
Maplehurst Gardens, Three Rivers.
Marvin, O. F., Holton.
Mayer, Jr., Michael, Merrill.
Merrill, W. F., South Haven.
Mershon, W. B., Lovells.
Michigan Nursery Co., Monroe.
Miller, Abner, Bravo.
Morrill, Roland, Benton Harbor.
Munson, J. Pomeroy, Grand Rapids.
Mutual Nurseries, Monroe.
Myers, P. J., Bridgman.
Myers & Merrifield, Gobleville.
Nelson & Son, J. A., Paw Paw.
Newell, Reuben, Highland Park.
Nieb, Daniel P., Niles.
Niles Nursery Co. The, Niles.
Nu-way Nurseries, Lansing.
Oakland Gardens Nursery, Detroit.
Orchard Lake Nursery, Orchard Lake.
Owens, Geo. B., Leslie.
Pitcher, W. D., Buchanan.
Pontiac Nursery Co., Detroit.
Potter, E. W., Leslie.
Prestage, J. G., Allegan.
Prudential Nursery Co., Kalamazoo.
Quandt, Elmer, Dearborn.
Rasmussen, R. J., Marlette.
Reeser, H. C., Niles.
Rice, Miss Greta B., Port Huron.
Robbins, A. L., Bangor.
Rokeley, J. N., Bridgman.
Rouse Fred, Woodville.
St. Joseph Nursery, The, St. Joseph.
Saier, Harry E., Lansing.
Schenck, Geo. H., Elsie.
Schild, H. J., Ionia.
Seel, J. J., Frankfort.
Shepard, Chas. E., Lawton.
Smith, Henry, Grand Rapids.
Spielman Bros., Adrian.
Taft, Howard A., South Haven.
Tindall, W. F., Boyne City.
Walcott & Cole, Levering.
Ward, Paul L., Hillsdale.
Westmacott, H. S., Montague.
Weston & Co., A. R., Bridgman.
Whitten, C. E., Bridgman.
Wilcox, C. W., Kalamazoo.
Wise, Ralph, Plainwell.
Wolverine Cooperative Nursery, Paw Paw.
Wolverine-Detroit Nursery, Detroit.

LICENSED DEALERS IN NURSERY STOCK.

Alferink, Albert, Holland.
Bemb Floral Co., L., Detroit.
Boyd, Joseph B., Traverse City.
Brown & Co., Clara, Jackson.
Buskirk, C. M., Big Rapids.
Clawson Nurseries, The, Clawson.
Cross, Eli, Grand Rapids.
Crowley-Milner Co., Detroit.
Davison Nursery Co., The, Davison.
Dean, George H., Shelbyville.
Derrickson, Henry, Coldwater.
Detroit Landscape Construction Co., Detroit.
Detroit Shade Tree Co., Detroit.
Edwards & Chamberlain Co., Kalamazoo.

Ellis, Daniel H., Saginaw.
Fair Oaks Nursery Co., Traverse City.
Freyling & Mendels, Grand Rapids.
Gibson & Son, S. B., Detroit.
Gleaner Clearing House, Detroit.
Grand Rapids Nursery Co., Grand Rapids.
Grohman, E. A., Saginaw.
Hallman, W. S., Coloma.
Harris Bros. Seed Co., Mt. Pleasant.
Healy, William, Bloomingdale.
Hotchkiss, Caleb, Detroit.
Hudson Co., The J. L., Detroit.
Hughes, Charles P., Hillsdale.
Isbell & Co., S. M., Jackson.
Jones, Sons & Co., J. R., Kalamazoo.
Knapp, J. W., Lansing.
Knoch, Gustav, Detroit.
Kresge Co., S. S., Detroit.
Nelson, Charles A., Northport.
Pearson & Co., D. S., Detroit.
Pult, Casper J., Detroit.
Rayl Co., T. B., Detroit.
Reed, W. F., Flint.
Shorewood Farms Co., Saugatuck.
Slanker Nursery Co., Benton Harbor.
Smith & Co., E. M., Detroit.
Stover, F. J., Traverse City.
Strittmatter, Adolph, Detroit.
Sweet L. H., Carsonville.
Trankla & Co., Chas., Grand Rapids.
Valley City Nurseries, Grand Rapids.
Van Bochove & Brother, G., Kalamazoo.
Vogt, D., Coldwater.
Walthers Dept. Store, Bay City.
Webb & Co., D. S., Traverse City.
Weller, Barend S., Holland.
Wells, R. H., Detroit.
Westgate Nursery Co., H. L., Monroe.
Witbeck, F. M., & Son.
Wolcott Nurseries, Jackson.

LICENSED FOREIGN NURSERIES.

Allen Nursery Co., Rochester, N. Y.
Augustine & Co., Normal, Ill.
Bogue, Nelson, Batavia, N. Y.
Brow Nursery Co., F. W., Rose Hill.
Brown Bros. Co., Rochester, N. Y.
Bryant & Son, Arthur, Princeton, Ill.
Bryant Bros., Dansville, N. Y.
Burr & Co., C. R., Manchester, Conn.
Central New York Nursery Co., Geneva, N. Y.
Charlton Nursery Co., Rochester, N. Y.
Chase Bros. Nursery Co., Rochester, N. Y.
Chase, Charles H., Rochester, N. Y.
Chase Nurseries, The, Geneva, N. Y.
Dreer, Henry A., Inc., Philadelphia, Pa.
Fairview Nurseries, The, Rochester N. Y.
First National Nurseries, Rochester, N. Y.
Fruit Growers' Nurseries, Newark, N. Y.
Guaranty Nursery Co., Rochester, N. Y.
Harman Nursery Co., M. H., Geneva, N. Y.
Harrison & Sons, J. G., Berlin, Maryland.
Hawks Nursery Co., Rochester, N. Y.
Hooker Brothers, Rochester, N.Y.
Huntsville Wholesale Nurseries, Huntsville, Ala.
Jewell Nursery Co., Lake City, Minn.
Jewett, Z. K., Sparta, Wis.
Knight & Bostwick, Newark, N.Y.

La Pointe Nursery Co., Geneva, N. Y.
Moon Co., The, Wm. H., Morrisville Pa.
Moore & Co., W. C., Newark, N.Y.
Nelson & Sons, Swain, Chicago, Ill.
Pennsylvania Nursery Co., Girard, Pa.
Perry Nursery Co., Rochester, N. Y.
Pickett, A. R., Clyde, Ohio.
Rhinelander Nursery Co., Rhinelander, Wis.
Rice Bros. Co., Geneva, N. Y.
Stark Bros Nursery Co., Louisiana, Missouri.
Stuart & Co., C. W., Newark, N. Y.
Taylor & Co., H. S., Rochester, N. Y.
Walton, Cary A., Greenfield, Indiana.
Weeks Nursery Co., C. H., Lyons, N. Y.
Western New York Nursery Co., Rochester, N. Y.
Westminster Nursery Co., Westminster, Maryland.
Wheelock & Congdon, North Collins, N. Y.
Woods, A. E., Greenfield, Ind.
Woolworth & Co., F. W., Buffalo, N. Y.

Respectfully submitted,
L. R. TAFT,
State Inspector of Nurseries and Orchards.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DEPARTMENT OF METEOROLOGY.

Dr. F. S. Kedzie, President, Michigan Agricultural College.
East Lansing, Mich.

Dear Dr. Kedzie—I have the honor to make the following report concerning the work of this department for the year ending June 30, 1917:

Eleven students enrolled in the fall term of 1916, for instruction in meteorology, and the usual course, along practical lines was given.

During February, 1917, a series of twenty lectures was given to the two-year Short Course students about 29 having enrolled for this subject.

Very respectfully,
D. A. SEELEY,
Instructor in Meteorology.

East Lansing, Mich., June 30, 1917.

METEOROLOGICAL TABLES.

METEOROLOGICAL TABLES.

Monthly Meteorological Summary, Lansing, Michigan, July, 1916.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	83	55	69	0	Partly cloudy	89
2	86	61	74	0	Clear	78
3	79	57	68	0	Clear	85
4	84	55	70	0	Clear	100
5	84	56	70	0	Clear	100
6	86	57	72	0	Clear	99
7	87	58	72	0	Clear	100
8	82	55	68	0	Clear	95
9	79	52	66	0	Clear	80
10	84	52	68	0	Clear	100
11	91	62	76	0	Clear	100
12	94	69	82	0	Partly cloudy	84
13	85	65	75	0.05	Partly cloudy	58
14	89	60	74	0	Clear	100
15	92	64	78	0	Partly cloudy	91
16	91	70	80	0.04	Partly cloudy	94
17	87	68	78	0	Clear	100
18	90	66	78	0	Clear	100
19	94	68	81	0	Clear	99
20	86	69	78	0	Partly cloudy	68
21	87	65	76	0	Clear	100
22	92	61	76	0	Partly cloudy	89
23	91	62	76	0	Clear	100
24	94	61	78	0	Clear	100
25	95	64	80	0	Clear	100
26	95	65	80	0	Clear	100
27	98	69	84	0	Clear	65
28	97	70	84	0	Partly cloudy	76
29	102	72	87	0	Clear	100
30	101	74	88	0	Clear	79
31	89	63	76	0	Clear	98

Mean highest temperature	89 5
Mean lowest temperature	62 7
Mean temperature for month	76 1
Total precipitation for month	0.09

WEATHER

Number days clear	23
Partly cloudy	8
Cloudy	0
With 0.01 or more of precipitation	2

SUNSHINE

Number hours sunshine	424 1
Possible hours sunshine	464 9
Percentage of possible	91

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	.....	.....
1864	74 5	1 25
1865	65 6	3.91
1866	71 7	4.19
1867	71 6	1 78
1868	77 2	1 11
1869	70.4	5 77
1870	74 4	8.02
1871	70.6	3.10
1872	74.9	3.36
1873	70 8	5.12
1874	72.0	2.56
1875	69 7	2.42
1876	72.5	2.10
1877	71 4	2.25
1878	73.0	2.96
1879	74.0	2.19
1880	68 0	6.27
1881	73 1	1.81
1882	67.5	2.32
1883	68.9	11.27
1884	68 0	2 60
1885	72.7	2.52
1886	70.7	0.65
1887	75.5	1.50
1888	70.5	2.40
1889	70 2	3.41
1890	71 1	0.92
1891	65 3	1.88
1892	70.3	2.00
1893	71.5	1.86
1894	73.2	0.86
1895	70.5	1.47
1896	71.8	6.73
1897	73.8	8 49
1898	70.0	1.34
1899	69.8	2.11
1900	69.6	4.15
1901	74.2	5.08
1902	70.6	7.13
1903	67.9	3.79
1904	69.2	1.97
1905	69.8	5.75
1906	70.8	2 23
1907	70 0	4.30
1908	73.2	1 03
1909	70.0	2.56
1910	71.0	1.53
1911	71.3	1 65
1912	69 6	5 06
1913	70 8	2.85
1914	71.0	1.65
1915	67.9	5 17
1916	76.1	0.09

BAROMETER—Mean 30.00 inches; highest 30.22 inches on 6th; lowest 29.68 inches on 2nd.

TEMPERATURE—Highest 102° on 29th; lowest 52° on 10th; greatest daily range 33° on 24th; least daily range 17° on 20th. normal for month 70.9°; excess or deficiency this month +5.2°; accumulated excess or deficiency since January 1st −134°.; average daily same period −0.6°; highest in 31 years 102° lowest 37°.

PRECIPITATION (in inches)—Total amount 0.09; normal 3.22; excess or deficiency this month −3.13; since Jan. 1st +0.23. Greatest amount in any 24 hour period 0.05 on 13th, total snowfall 0.0 inches.

WIND—Prevailing direction east; total movement 2 505 miles; average hourly velocity 3.1 miles; maximum velocity 21, from the northwest on 2nd.

DATES OF—Auroras 0; dense fog 0; hail 0; sleet 0; thunderstorms 2, 13, 15, 16, 20, 22, 30; halos: solar 1, 28; lunar 0; frost: killing 0; heavy 0; light 0.

DEWEY A. SEELEY
Local Forecaster.

Monthly Meteorological Summary, Lansing, Michigan, August, 1916.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation, in inches.	Character of day.	Percentage of possible sunshine.
1	81	55	68	0	Clear	96
2	87	49	68	0	Clear	100
3	90	62	76	0	Cloudy	44
4	92	64	78	0	Partly cloudy	73
5	89	70	80	0.23	Clear	76
6	91	72	83	0	Clear	94
7	93	70	82	0.63	Partly cloudy	52
8	83	66	74	0	Partly cloudy	54
9	82	59	70	0	Clear	100
10	85	59	72	0.22	Partly cloudy	68
11	85	63	74	0	Cloudy	38
12	82	55	68	0.02	Partly cloudy	82
13	73	50	62	0.14	Clear	100
14	71	45	58	0	Cloudy	66
15	81	48	64	0	Partly cloudy	75
16	87	62	74	0	Partly cloudy	76
17	90	60	75	0	Partly cloudy	87
18	88	65	76	0.11	Cloudy	43
19	96	70	83	0	Partly cloudy	100
20	98	68	83	0	Clear	100
21	96	68	82	0	Clear	100
22	88	61	74	0	Clear	100
23	78	52	65	0	Clear	98
24	86	54	70	0.07	Clear	83
25	79	52	66	0	Clear	94
26	65	54	60	0.16	Cloudy	0
27	71	45	58	0	Clear	93
28	75	41	58	0	Clear	92
29	80	49	64	0	Clear	98
30	81	51	68	0	Clear	98
31	83	54	68	0	Partly cloudy	72

Mean highest temperature	84.2
Mean lowest temperature	57.9
Mean temperature for month	71.0
Total precipitation for month	1.58

WEATHER

Number days clear	16
Partly cloudy	10
Cloudy	5
With 0.01 or more of precipitation	8

SUNSHINE

Number hours sunshine	340.2
Possible hours sunshine	430.7
Percentage of possible	79

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	....	3.00
1864	70.7	0.39
1865	65.8	3.38
1866	62.6	3.44
1867	69.8	1.74
1868	70.3	2.42
1869	70.6	4.85
1870	70.1	4.53
1871	71.2	1.42
1872	71.2	4.18
1873	69.5	0.80
1874	69.4	1.28
1875	65.5	1.47
1876	71.6	1.28
1877	68.5	6.57
1878	70.2	1.85
1879	70.0	1.61
1880	68.6	6.02
1881	72.7	1.63
1882	69.5	5.72
1883	64.9	0.18
1884	66.9	1.30
1885	63.6	6.75
1886	69.3	4.69
1887	68.0	0.89
1888	67.6	1.87
1889	68.6	0.68
1890	65.4	3.60
1891	67.9	4.82
1892	68.3	5.12
1893	68.1	0.56
1894	68.8	0.00
1895	71.2	4.64
1896	70.0	4.73
1897	65.9	1.69
1898	69.0	2.73
1899	71.4	0.70
1900	73.3	2.98
1901	68.4	2.49
1902	64.2	0.68
1903	64.3	6.73
1904	65.9	3.26
1905	69.6	3.92
1906	73.5	4.35
1907	65.5	2.87
1908	68.4	3.99
1909	71.0	1.61
1910	68.2	1.76
1911	68.2	1.48
1912	65.7	2.19
1913	69.4	5.60
1914	68.9	3.33
1915	63.4	3.63
1916	71.0	1.58

BAROMETER—Mean, 30.01 inches; highest, 30.29 inches, on 1st; lowest, 29.68 inches, on 24th.

TEMPERATURE—Highest, 98°, on 20th; lowest, 41°, on 28th; greatest daily range, 38°, on 2nd; least daily range, 11°, on 26th; normal for month, 68.4°; excess or deficiency this month, +2.6°; accumulated excess or deficiency since January 1st, −52°; average daily, same period, −0.2°; highest in 31 years, 99°; lowest, 32°.

PRECIPITATION (in inches)—Total amount, 1.58; normal, 2.63; excess or deficiency this month, −1.05; since January 1st, −0.82. Greatest amount in any 24 hour period, 0.63, on 7th; total snowfall, 0.0 in.

WIND—Prevailing direction, southwest; total movement, 2,859 miles; average hourly velocity, 3.8 miles; maximum velocity, 19, from the west on 3rd.

DATES OF—Auroras, 26; dense fog, 0; hail, 0; thunderstorms, 3, 4, 7, 8, 10, 16, 18; halos: solar, 4, 17, 18, 19, 27, 31; lunar, 0; frost: killing, 0; heavy, 0; light, 28.

DEWEY A. SEELEY,
Local Forecaster.

Monthly Meteorological Summary, Lansing, Michigan, September, 1916.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation, in inches.	Character of day.	Percentage of possible sunshine.
1	75	62	68	0.01	Cloudy	3
2	71	48	60	0	Clear	98
3	76	41	58	0	Clear	100
4	80	56	68	0.10	Cloudy	27
5	84	64	74	0.03	Partly cloudy	61
6	87	64	76	0	Partly cloudy	77
7	88	67	78	0.10	Cloudy	42
8	78	52	65	0	Partly cloudy	68
9	79	46	62	0	Clear	98
10	77	50	64	0	Partly cloudy	66
11	86	62	74	0	Clear	98
12	87	65	76	0	Clear	87
13	74	52	63	0.04	Partly cloudy	67
14	70	51	60	0	Partly cloudy	45
15	60	43	52	0	Partly cloudy	30
16	57	39	48	0	Partly cloudy	58
17	60	37	48	0.03	Partly cloudy	66
18	62	33	48	0	Partly cloudy	81
19	69	30	50	0	Partly cloudy	80
20	78	46	62	0	Clear	99
21	70	49	60	0.01	Partly cloudy	36
22	66	47	56	0	Cloudy	21
23	64	41	52	0	Partly cloudy	33
24	69	39	54	0	Partly cloudy	61
25	78	44	61	0	Clear	100
26	74	55	64	0.38	Cloudy	0
27	71	59	65	1.34	Cloudy	0
28	67	49	58	0.13	Cloudy	30
29	50	31	40	0	Partly cloudy	39
30	62	30	46	0	Clear	96
31	...	...	...	...	...	...

Mean highest temperature	72.3
Mean lowest temperature	48.4
Mean temperature for month	60.4
Total precipitation for month	2.17

WEATHER

Number days clear	8
Partly cloudy	15
Cloudy	7
With 0.01 or more of precipitation	10

SUNSHINE

Number hours sunshine	222.1
Possible hours sunshine	374.8
Percentage of possible	59

This month since 1863.

Year	Mean temperature.	Total precipitation.
1863	....	0.89
1864	59.6	3.53
1865	67.7	4.79
1866	55.8	5.80
1867	56.6	1.42
1868	58.8	2.95
1869	63.5	1.43
1870	63.7	2.85
1871	59.1	0.79
1872	62.0	5.21
1873	67.4	3.50
1874	62.8	1.27
1875	58.5	2.89
1876	56.3	3.65
1877	61.3	1.38
1878	63.2	3.41
1879	56.2	3.19
1880	55.8	3.10
1881	69.7	2.91
1882	59.9	0.67
1883	56.4	2.34
1884	65.1	3.34
1885	58.9	3.75
1886	62.1	5.40
1887	58.9	4.72
1888	57.8	1.89
1889	61.2	0.79
1890	57.7	1.67
1891	65.1	1.10
1892	60.8	2.17
1893	58.4	1.84
1894	63.7	2.59
1895	66.6	0.85
1896	57.6	6.73
1897	62.9	0.80
1898	63.3	3.00
1899	57.0	2.14
1900	63.2	0.89
1901	61.7	1.67
1902	58.7	5.88
1903	61.0	2.86
1904	62.0	2.35
1905	63.8	3.21
1906	67.5	0.76
1907	61.8	4.68
1908	66.4	0.65
1909	60.4	1.51
1910	60.2	2.74
1911	61.5	5.05
1912	62.7	3.33
1913	61.0	1.53
1914	60.3	2.65
1915	63.2	6.55
1916	60.4	2.17

BAROMETER—Mean, 30.02 inches; highest, 30.37 inches, on 3rd; lowest, 29.62 inches, on 27th.

TEMPERATURE—Highest, 88°, on 7th; lowest, 30°, on 19th; greatest daily range, 39°, on 19th; least daily range, 12°, on 27th; normal for month, 61.6°; excess or deficiency this month, −1.2°; accumulated excess or deficiency since January 1st, −89°; average daily, same period, −0.3°; highest in 31 years, 99°; lowest, 21°.

PRECIPITATION (in inches)—Total amount, 2.17; normal, 2.62; excess or deficiency this month, −0.45; since January 1st −1.27; greatest amount in any 24 hour period, 1.34; on 27th; total snowfall, 0.0 in.

WIND—Prevailing direction, southwest; total movement, 3,916 miles; average hourly velocity, 5.4 miles; maximum velocity, 20, from the southwest on 27th.

DATES OF—Auroras, 0; dense fog, 0; hail, 0; thunderstorms, 4, 7, 21, 26, 27; halos: solar, 10, 19; lunar, 0; frost: killing, 19; heavy, 18; light, 0.

DEWEY A. SEELEY,
Local Forecaster.

Monthly Meteorological Summary, Lansing, Michigan, October, 1916.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation, in inches.	Character of day.	Percentage of possible sunshine.
1	61	37	50	0	Clear	100
2	73	40	56	0	Clear	100
3	79	42	60	0	Clear	100
4	81	47	64	0	Clear	100
5	83	48	66	0	Clear	100
6	70	43	56	0	Partly cloudy	83
7	80	42	61	0	Clear	100
8	84	55	70	0	Partly cloudy	80
9	55	33	44	0.18	Cloudy	56
10	55	29	42	0	Clear	100
11	60	31	46	0	Clear	100
12	62	36	49	0.35	Cloudy	40
13	57	37	47	0.43	Cloudy	30
14	61	31	46	0	Clear	95
15	58	42	50	0	Cloudy	6
16	65	42	54	0.11	Cloudy	55
17	49	29	39	0	Clear	100
18	54	29	42	0 06	Partly cloudy	83
19	54	46	50	0 72	Cloudy	0
20	57	32	44	0.41	Cloudy	1
21	41	36	38	0 01	Cloudy	0
22	52	32	42	0	Clear	100
23	61	38	50	0	Clear	90
24	48	43	46	0.03	Cloudy	0
25	54	40	47	0.10	Cloudy	0
26	48	35	42	0	Clear	87
27	54	31	42	0 09	Partly cloudy	64
28	60	29	44	0	Partly cloudy	80
29	69	44	56	0	Partly cloudy	85
30	58	41	50	0	Partly cloudy	60
31	55	41	48	0.04	Cloudy	24

Mean highest temperature	61.3
Mean lowest temperature	38 1
Mean temperature for month	49 7
Total precipitation for month	2 53

WEATHER

Number days clear	13
Partly cloudy	7
Cloudy	11
With 0.01 or more of precipitation	12

SUNSHINE

Number hours sunshine	224 9
Possible hours sunshine	341 9
Percentage of possible	66

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	....	1 01
1864	45 7	1.86
1865	46 5	2 76
1866	49 5	3.57
1867	50 6	2 11
1868	45 2	1 11
1869	49 8	1 72
1870	52 5	2.29
1871	53.9	1.43
1872	47.4	0.67
1873	44 7	1.91
1874	49.1	0 49
1875	42 9	5.81
1876	43 7	1 26
1877	50 8	5 69
1878	48.3	1 99
1879	57.3	1.57
1880	46 2	2.84
1881	52 5	5.56
1882	52.7	2 64
1883	46 2	3.66
1881	50 9	5.73
1885	45 0	3.08
1886	52.4	0.95
1887	45 0	1.86
1888	45 7	3.00
1889	44 2	0 65
1890	49.1	4 56
1891	48 8	0.82
1892	48 3	0 78
1893	49.7	3 61
1894	49.8	1.91
1895	45 0	1 41
1896	44.6	1.06
1897	53 1	2 15
1898	49 6	3 55
1899	53 2	2.68
1900	56 6	2.77
1901	49 6	4.61
1902	49.6	1.53
1903	51.0	2.01
1904	48.6	1.90
1905	50.9	1.75
1906	49.2	2.36
1907	46.0	2.22
1908	51 6	0.82
1909	46 2	0.71
1910	51 8	2.27
1911	48.0	5.00
1912	50.4	3.44
1913	50.2	3.30
1914	54.6	2.81
1915	51.1	0.70
1916	49.7	2.53

BAROMETER—Mean, 30.07 inches; highest, 30.47 inches, on 10th; lowest, 29.24 inches, on 20th.

TEMPERATURE—Highest, 84°, on 8th; lowest, 29°, on 28th; greatest daily range, 38°, on 7th; least daily range, 5°, on 24th; normal for month, 49.0°; excess or deficiency this month, +0.7°; accumulated excess or deficiency since January 1st, −68° average daily, same period, −0.2°; highest in 31 years, 90°; lowest, 10°.

PRECIPITATION (in inches)—Total amount, 2.53; normal, 2.23; excess or deficiency this month, +0.30; since January 1st, +0.97; greatest amount in any 24 hour period, 0.78; on 12th and 13th; total snowfall, 0.3 inches.

WIND—Prevailing direction, southwest; total movement, 4,800 miles; average hourly velocity, 6.4 miles; maximum velocity, 30, from the northwest, on 16th.

DATES OF—Auroras, 6; dense fog, 0; hail, 0; sleet, 0; thunderstorms, 0; halos: solar, 6, 18, 28, 29; lunar, 0; frost: killing, (frosts not recorded.)

DEWEY A. SEELEY,
Local Forecaster.

Monthly Meteorological Summary, Lansing, Michigan, November, 1916.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation, in inches.	Character of day.	Percentage of possible sunshine.
1	59	35	47	0	Clear	100
2	58	34	46	0	Clear	100
3	57	29	43	0.35	Cloudy	67
4	58	40	49	0	Partly cloudy	65
5	55	31	43	0	Clear	81
6	62	37	50	0	Clear	100
7	71	49	60	0	Partly cloudy	82
8	66	54	60	0.04	Cloudy	37
9	59	38	48	0.27	Partly cloudy	41
10	54	31	42	0.01	Cloudy	29
11	40	25	32	0	Cloudy	44
12	45	34	40	0	Partly cloudy	51
13	35	28	32	0.06	Cloudy	0
14	30	19	24	0.01	Cloudy	5
15	25	16	20	0	Cloudy	23
16	32	15	24	0	Cloudy	5
17	37	24	30	0	Cloudy	26
18	41	23	32	0	Partly cloudy	67
19	55	27	41	0	Clear	98
20	44	26	35	0	Cloudy	5
21	44	24	34	0	Clear	100
22	48	26	37	0.15	Cloudy	33
23	50	36	43	0.51	Cloudy	0
24	36	21	28	0.03	Cloudy	1
25	27	16	22	0	Cloudy	18
26	43	16	30	0	Cloudy	46
27	52	38	45	0	Cloudy	20
28	53	46	50	0.08	Cloudy	8
29	53	34	44	0.17	Cloudy	8
30	36	29	32	0	Cloudy	2
31						

Mean highest temperature	47.5
Mean lowest temperature	30.0
Mean temperature for month	38.8
Total precipitation for month	1.68

WEATHER

Number days clear	6
Partly cloudy	5
Cloudy	19
With 0.01 or more of precipitation	11

SUNSHINE

Number hours sunshine	125.0
Possible hours sunshine	292.1
Percentage of possible	43

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	....	0.40
1864	37.9	4.12
1865	38.6	0.68
1866	37.9	2.60
1867	40.4	1.77
1868	36.8	2.44
1869	32.1	1.93
1870	38.4	0.91
1871	32.0	1.25
1872	29.8	0.98
1873	28.5	2.03
1874	35.0	1.61
1875	33.0	1.11
1876	36.3	0.91
1877	35.2	3.67
1878	36.3	2.16
1879	38.2	4.55
1880	27.5	2.32
1881	38.2	4.09
1882	36.3	1.83
1883	38.1	3.98
1884	34.1	1.84
1885	37.2	2.90
1886	33.9	1.48
1887	35.7	2.28
1888	38.5	3.12
1889	37.4	2.67
1890	39.1	2.30
1891	34.0	3.34
1892	34.2	1.84
1893	35.6	2.19
1894	32.5	0.97
1895	35.4	3.87
1896	37.1	1.05
1897	36.5	2.94
1898	33.1	2.72
1899	39.7	1.72
1900	35.3	5.10
1901	32.8	1.21
1902	43.0	2.46
1903	34.0	1.45
1904	40.0	0.04
1905	35.8	2.25
1906	37.0	2.66
1907	36.0	1.83
1908	38.2	1.82
1909	44.5	3.74
1910	34.0	1.37
1911	33.8	3.40
1912	38.6	2.86
1913	41.7	2.38
1914	37.6	1.40
1915	39.8	2.23
1916	38.8	1.68

BAROMETER—Mean, 30.06 inches; highest, 30.52 inches, on 11th; lowest, 29.05 inches, on 23rd.

TEMPERATURE—Highest, 71°, on 7th; lowest, 15°, on 16th; greatest daily range, 28°, on 3rd; least daily range, 7°, on 28th; normal for month, 36.8°; excess or deficiency this month, +2.0°; accumulated excess or deficiency since January 1st, −9°; average daily, same period, 0.0°; highest in 31 years, 72°; lowest, 0°.

PRECIPITATION (in inches)—Total amount, 1.68; normal, 2.41; excess or deficiency this month, −0.73; since January 1st, −1.70; greatest amount in any 24 hour period, 0.65 on 23rd; total snowfall, 0.4 in.

WIND—Prevailing direction, southwest; total movement, 5,590 miles; average hourly velocity, 7.8 miles; maximum velocity 26, from the northwest, on 24th.

DATES OF—Auroras, 0; dense fog, 20; hail, 0; sleet, 13; thunderstorms, 3; halos solar, 3, 4, 7, 22, 26; lunar, 0; frost: killing, frosts not recorded.)

DEWEY A. SEELEY,
Local Forecaster.

Monthly Meteorological Summary, Lansing, Michigan, December, 1916.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation, in inches.	Character of day.	Percentage of possible sunshine.
1	47	29	38	0	Clear	100
2	50	26	38	0	Clear	100
3	44	34	39	0.01	Cloudy	0
4	59	41	50	0.04	Cloudy	0
5	50	36	43	0	Clear	77
6	50	30	40	0	Clear	100
7	53	37	45	0.04	Cloudy	0
8	53	33	43	0.68	Cloudy	0
9	33	21	27	0.28	Cloudy	1
10	33	16	24	0	Clear	99
11	30	19	24	0.14	Cloudy	0
12	27	11	20	0.09	Cloudy	19
13	23	13	18	0.04	Cloudy	26
14	17	2	10	0.03	Cloudy	47
15	8	−7	0	0	Cloudy	49
16	10	−2	4	0.10	Cloudy	16
17	23	−1	11	0.02	Partly cloudy	59
18	14	−3	6	0	Cloudy	30
19	21	−4	8	0.07	Cloudy	2
20	21	11	16	0.01	Cloudy	46
21	24	5	14	0	Clear	100
22	18	2	10	0	Partly cloudy	62
23	24	2	13	0	Cloudy	22
24	32	6	19	0.12	Cloudy	0
25	28	14	21	0	Cloudy	36
26	35	19	27	0.37	Cloudy	0
27	41	20	30	0.06	Clear	80
28	23	13	18	0	Cloudy	33
29	18	12	15	0.01	Cloudy	0
30	18	6	12	0	Cloudy	30
31	30	5	18	0	Clear	89

Mean highest temperature	30.9
Mean lowest temperature	14.5
Mean temperature for month	22.7
Total precipitation for month	2.11

WEATHER

Number days clear	8
Partly cloudy	2
Cloudy	21
With 0.01 or more of precipitation	17

SUNSHINE

Number hours sunshine	110.8
Possible hours sunshine	280.8
Percentage of possible	39

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	....	1.71
1864	24.4	3.20
1865	26.7	1.43
1866	25.5	1.90
1867	25.3	1.34
1868	21.2	1.35
1869	28.2	2.11
1870	21.8	2.57
1871	21.1	1.76
1872	15.7	1.06
1873	29.5	3.02
1874	27.0	0.37
1875	31.6	2.80
1876	15.2	1.29
1877	36.6	1.03
1878	21.3	2.27
1879	27.5	3.55
1880	22.1	0.85
1881	34.3	1.75
1882	24.8	0.88
1883	26.4	1.28
1884	24.7	4.15
1885	27.8	2.14
1886	19.7	1.56
1887	27.3	3.32
1888	30.4	1.20
1889	36.8	2.61
1890	26.4	1.12
1891	34.6	1.47
1892	25.6	1.52
1893	27.6	2.28
1894	30.1	0.93
1895	28.5	5.39
1896	28.1	0.80
1897	25.6	2.02
1898	24.8	1.42
1899	25.0	1.51
1900	26.7	0.50
1901	21.6	3.00
1902	24.8	2.89
1903	19.7	1.75
1904	21.7	1.42
1905	30.2	2.54
1906	26.8	1.85
1907	22.7	4.19
1908	26.4	2.08
1909	23.0	2.91
1910	21.6	1.28
1911	31.1	1.58
1912	31.0	1.20
1913	31.8	0.55
1914	21.6	1.57
1915	24.8	1.01
1916	22.7	2.11

BAROMETER—Mean, 29.97 inches; highest, 30.53 inches, on 14th; lowest, 29.56 inches, on 16th.

TEMPERATURE—Highest, 59°, on 4th; lowest, −7°, on 15th; greatest daily range, 26°, on 24th; least daily range, 6°, on 29th; normal for month, 26.8°; excess or deficiency this month, −4.1°; accumulated excess or deficiency since January 1st, −138°; average daily, same period, −0.4°; highest in 31 years, 62°; lowest, −24°.

PRECIPITATION (in inches)—Total amount, 2.11; normal, 2.08; excess or deficiency this month, +0.03; since January 1st, −1.67; greatest amount in any 24 hour period, 0.86, on 8th and 9th; total snowfall, 11.6 in.

WIND—Prevailing direction, west; total movement, 4,612 miles; average hourly velocity, 6.2 miles; maximum velocity, 22, from the west, on 5th.

DATES OF—Auroras, 0; dense fog, 0; hail, 0; sleet, 7, 26; thunderstorms, 8; halos: solar, 20, 21; lunar, 2, 3, 4, 14; frost: killing; (frosts not recorded.)

DEWEY A. SEELEY,
Local Forecaster.

Monthly Meteorological Summary, Lansing, Michigan, January, 1917.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation, in inches.	Character of day.	Percentage of possible sunshine.
1	36	29	32	0	Cloudy	0
2	35	26	30	0	Partly cloudy	59
3	37	27	32	0.01	Partly cloudy	22
4	42	27	34	0	Cloudy	43
5	37	24	30	0.60	Cloudy	29
6	38	18	28	0	Partly cloudy	63
7	37	17	27	0	Cloudy	36
8	43	21	32	0	Clear	97
9	38	32	35	0.07	Cloudy	22
10	32	2	17	0.31	Cloudy	36
11	11	−10	0	0	Partly cloudy	78
12	17	−8	4	0.18	Cloudy	0
13	23	6	14	0.01	Cloudy	12
14	12	−5	4	0	Partly cloudy	85
15	13	−4	4	0	Cloudy	31
16	19	−9	5	0	Clear	100
17	24	7	16	0	Partly cloudy	59
18	26	14	20	0.01	Cloudy	5
19	23	10	16	0	Cloudy	12
20	30	17	24	0	Cloudy	0
21	36	17	26	0.29	Cloudy	0
22	30	10	20	0	Cloudy	41
23	24	3	14	0	Partly cloudy	77
24	27	17	22	0	Cloudy	0
25	20	8	14	0.01	Partly cloudy	64
26	16	0	8	0	Partly cloudy	79
27	32	9	20	0.02	Partly cloudy	65
28	39	16	28	0	Partly cloudy	61
29	42	29	36	0	Cloudy	0
30	36	23	30	0	Partly cloudy	75
31	29	21	25	0.04	Cloudy	0

Mean highest temperature	29.2
Mean lowest temperature	12.7
Mean temperature for month	21.0
Total precipitation for month	1.55

WEATHER

Number days clear	2
Partly cloudy	12
Cloudy	17
With 0.01 or more of precipitation	11

SUNSHINE

Number hours sunshine	117.9
Possible hours sunshine	292.5
Percentage of possible	40

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	.....	.....
1864	22.3	0.94
1865	21.1	0.65
1866	21.2	2.03
1867	17.6	1.68
1868	19.0	1.47
1869	29.4	0.87
1870	25.4	1.93
1871	24.8	3.95
1872	21.6	0.42
1873	15.9	2.98
1874	27.7	3.53
1875	12.9	1.81
1876	30.2	1.63
1877	18.1	1.33
1878	29.1	1.12
1879	19.2	0.49
1880	37.1	2.67
1881	17.0	2.27
1882	24.9	1.47
1883	14.4	1.53
1884	15.5	1.23
1885	15.3	2.70
1886	18.8	2.66
1887	18.2	3.25
1888	15.4	2.18
1889	28.0	1.53
1890	31.5	2.31
1891	26.7	0.82
1892	19.2	0.96
1893	14.8	1.78
1894	26.9	1.37
1895	17.5	1.04
1896	24.6	0.79
1897	22.3	4.17
1898	24.9	3.07
1899	21.7	2.03
1900	25.6	1.17
1901	22.2	1.51
1902	20.5	0.43
1903	20.7	1.20
1904	14.4	2.82
1905	18.2	1.07
1906	31.8	1.99
1907	23.2	3.97
1908	23.8	1.89
1909	26.6	2.16
1910	23.4	2.52
1911	25.2	1.43
1912	9.2	0.80
1913	26.2	3.10
1914	27.0	2.98
1915	20.4	1.54
1916	27.6	3.11
1917	21.0	1.55

BAROMETER—Mean, 30.00 inches; highest, 30.88 inches, on 15th; lowest, 29.16 inches, on 21st.

TEMPERATURE—Highest, 43°, on 8th; lowest, −10°, on 11th; greatest daily range, 30°, on 10th; least daily range, 6°, on 9th; normal for month, 22.7°; excess or deficiency this month, −1.7°; accumulated excess or deficiency since January 1st, −56°; average daily, same period, −1.7°; highest in 32 years, 63°; lowest, −26°.

PRECIPITATION (in inches)—Total amount, 1.55; normal, 2.09; excess or deficiency this month; −0.54; since January 1st, −0.54; greatest amount in any 24 hour period, 0.60, on 5th; total snowfall, 13.0 inches.

WIND—Prevailing direction, southwest; total movement, 5,699 miles; average hourly velocity, 7.7 miles; maximum velocity, 30, from the southwest, on 21st.

DATES OF—Auroras, 0; dense fog, 29; hail, 0; sleet, 0; thunderstorms, 0; halos: solar, 10, 22, 26, 30; lunar, 2, 30; frost: killing, (frosts not recorded.)

DEWEY A. SEELEY,
Local Forecaster.

Monthly Meteorological Summary, Lansing, Michigan, February, 1917.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation, in inches.	Character of day.	Percentage of possible sunshine.
1	21	1	11	0.02	Partly cloudy	65
2	7	−4	2	0.01	Cloudy	57
3	14	−2	6	0.05	Cloudy	41
4	14	0	7	0.10	Cloudy	26
5	15	0	8	0.02	Cloudy	51
6	25	11	18	0	Cloudy	54
7	30	25	28	0.02	Cloudy	0
8	30	−5	12	0.06	Partly cloudy	55
9	13	−12	0	0	Partly cloudy	74
10	12	−5	4	0.01	Partly cloudy	53
11	8	−17	−4	0	Clear	94
12	7	−21	−7	0	Clear	100
13	22	2	12	0.04	Cloudy	0
14	25	−5	10	0	Partly cloudy	59
15	26	9	18	0	Partly cloudy	65
16	32	22	27	0.01	Partly cloudy	52
17	44	15	30	0	Partly cloudy	68
18	24	8	16	0	Clear	95
19	32	14	23	0.11	Cloudy	0
20	28	10	19	0	Cloudy	25
21	33	7	20	0.01	Partly cloudy	69
22	33	11	22	0.05	Cloudy	38
23	42	24	33	0.11	Partly cloudy	53
24	24	12	18	0	Cloudy	48
25	45	12	28	0	Cloudy	0
26	45	22	34	0	Cloudy	0
27	28	15	22	0	Partly cloudy	80
28	30	11	20	0	Partly cloudy	100
29						
30						
31						

Mean highest temperature	25.3
Mean lowest temperature	5.7
Mean temperature for month	15.5
Total precipitation for month	0.62

WEATHER

Number days clear	3
Partly cloudy	12
Cloudy	13
With 0.01 or more of precipitation	14

SUNSHINE

Number hours sunshine	149.9
Possible hours sunshine	295.2
Percentage of possible	51

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	......	......
1864	27.3	0.27
1865	27.6	1.76
1866	22.7	2.28
1867	30.9	3.23
1868	18.7	1.28
1869	26.7	2.95
1870	24.2	1.20
1871	25.6	1.73
1872	21.3	0.46
1873	19.1	0.77
1874	25.5	1.55
1875	8.0	2.20
1876	27.4	3.04
1877	32.3	0.00
1878	28.1	2.74
1879	20.4	1.43
1880	29.2	1.62
1881	21.6	3.77
1882	35.1	2.28
1883	19.8	4.50
1884	23.4	3.69
1885	8.9	0.73
1886	22.3	1.35
1887	24.3	5.71
1888	22.0	1.70
1889	18.3	1.17
1890	31.5	1.79
1891	26.7	2.20
1892	27.3	1.93
1893	21.3	1.83
1894	21.2	0.53
1895	16.4	0.12
1896	24.3	1.51
1897	26.4	0.67
1898	23.8	1.82
1899	16.8	1.51
1900	17.4	3.44
1901	12.8	1.83
1902	18.6	0.44
1903	20.6	1.58
1904	12.0	3.30
1905	15.8	1.25
1906	23.6	1.12
1907	19.2	0.25
1908	21.6	3.19
1909	28.4	2.36
1910	21.9	2.65
1911	27.6	1.77
1912	15.8	2.04
1913	20.0	1.65
1914	12.7	0.79
1915	29.4	2.10
1916	19.2	0.69
1917	15.5	0.62

BAROMETER—Mean, 30.02 inches; highest, 30.78 inches, on 12th; lowest, 29.41 inches, on 17th.

TEMPERATURE—Highest, 45°, on 25th; lowest, −21°, on 12th; greatest daily range, 35°, on 8th; least daily range, 5°, on 7th; normal for month, 21.6°; excess or deficiency this month, −6.1°; accumulated excess or deficiency since January 1st, −224°; average daily, same period, — 3.8°; highest in 32 years, 62°; lowest, −25°.

PRECIPITATION (in inches)—Total amount, 0.62; normal, 2.02; excess or deficiency this month, −1.40; since January 1st, −1.94; greatest amount in any 24 hour period, 0.16; on 22nd and 23rd; total snowfall, 5.5 inches.

WIND—Prevailing direction, northwest; total movement, 5,287 miles; average hourly velocity, 7.9 miles; maximum velocity, 24, from the northwest, on 2nd.

DATES OF—Auroras, 0; dense fog, 0; hail, 0; sleet, 19; thunderstorms, 0; halos: solar, 21, 22, 27, 28; lunar, 2; frost: killing, (frosts not recorded.)

DEWEY A. SEELEY,
Local Forecaster.

Monthly Meteorological Summary, Lansing, Michigan, March, 1917.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation, in inches.	Character of day.	Percentage of possible sunshine.
1	27	14	20	0	Clear	100
2	32	13	22	0	Partly cloudy	73
3	37	18	28	0	Cloudy	35
4	24	9	16	0	Partly cloudy	67
5	23	10	16	0	Partly cloudy	77
6	40	12	26	0	Cloudy	56
7	38	30	34	0.08	Cloudy	0
8	34	30	32	0.02	Cloudy	0
9	35	25	30	0	Partly cloudy	43
10	50	32	41	0	Cloudy	15
11	54	30	42	0.19	Cloudy	5
12	38	27	32	0	Clear	99
13	33	26	30	0.37	Cloudy	0
14	34	29	32	0.12	Cloudy	2
15	35	29	32	0	Cloudy	15
16	42	29	36	0.08	Cloudy	1
17	41	27	34	0.04	Cloudy	0
18	31	14	22	0.05	Partly cloudy	69
19	38	11	24	0	Clear	79
20	46	30	38	0	Partly cloudy	78
21	51	29	40	0	Partly cloudy	90
22	59	27	43	0	Clear	100
23	63	35	49	0.47	Cloudy	8
24	52	29	40	0	Clear	84
25	65	39	52	0	Clear	97
26	68	35	52	0.59	Partly cloudy	67
27	41	32	36	0.34	Cloudy	46
28	49	29	39	0.01	Partly cloudy	42
29	46	32	39	0	Partly cloudy	43
30	52	27	40	0	Partly cloudy	73
31	66	45	56	0.52	Cloudy	3

Mean highest temperature	43.4
Mean lowest temperature	25.9
Mean temperature for month	34.6
Total precipitation for month	2.88

WEATHER

Number days clear	6
Partly cloudy	11
Cloudy	14
With 0.01 or more of precipitation	13

SUNSHINE

Number hours sunshine	175.5
Possible hours sunshine	370.5
Percentage of possible	47

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	....	....
1864	31.7	2.26
1865	37.0	2.79
1866	29.1	3.39
1867	29.7	0.68
1868	37.8	4.65
1869	27.6	1.65
1870	30.3	3.01
1871	38.2	3.91
1872	24.8	2.04
1873	28.3	1.73
1874	32.3	1.79
1875	26.2	1.02
1876	30.6	4.84
1877	24.5	5.60
1878	40.9	3.12
1879	33.2	1.57
1880	35.5	1.70
1881	30.3	2.66
1882	36.0	3.58
1883	24.9	0.71
1884	29.9	3.67
1885	21.3	0.58
1886	31.3	2.63
1887	28.3	1.78
1888	27.0	1.88
1889	37.6	1.22
1890	28.2	1.54
1891	29.3	2.41
1892	29.9	1.31
1893	28.2	2.82
1894	40.1	1.25
1895	27.2	0.27
1896	28.7	1.31
1897	33.0	2.08
1898	37.0	3.59
1899	26.3	3.30
1900	23.6	1.88
1901	31.1	2.94
1902	38.0	3.16
1903	41.0	1.25
1904	30.2	3.45
1905	35.4	3.15
1906	26.2	1.86
1907	38.6	2.84
1908	34.8	2.19
1909	29.9	0.90
1910	44.0	0.40
1911	32.7	1.21
1912	22.4	1.92
1913	31.0	3.76
1914	31.1	1.52
1915	30.1	0.78
1916	26.2	3.09
1917	34.6	2.88

BAROMETER—Mean, 29.99 inches; highest, 30.51 inches, on 1st; lowest, 29.28 inches, on 23rd.

TEMPERATURE—Highest, 68°, on 26th; lowest, 9°, on 4th; greatest daily range, 33°, on 26th; least daily range, 4°, on 8th; normal for month, 32.3°; excess or deficiency this month, +3.3°; accumulated excess or deficiency since January 1st, −125°; average daily, same period, −1.6°; highest in 32 years, 82°; lowest, −12°.

PRECIPITATION (in inches)—Total amount, 2.88; normal, 2.26; excess or deficiency this month, +0.62; since January 1st, −1.32; greatest amount in any 24 hour period, 0.93, on 26th and 27th; total snowfall, 3.6 inches.

WIND—Prevailing direction, southwest; total movement, 7,169 miles; average hourly velocity, 9.6 miles; maximum velocity, 34; from the northwest, on 28th.

DATES OF—Auroras, 0; dense fog, 0; hail, 23; sleet, 7, 13, 16; thunderstorms, 23, 26, 31; halos: solar, 2, 6, 9, 10, 20, 27, 30; lunar, 1, 2, 3; frost: killing; (frosts not recorded.)

DEWEY A. SEELEY,
Local Forecaster.

Monthly Meteorological Summary, Lansing, Michigan, April, 1917.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation, in inches.	Character of day.	Percentage of possible sunshine.
1	49	37	43	0.26	Cloudy	0
2	47	29	38	0.15	Cloudy	30
3	54	27	40	0	Partly cloudy	67
4	58	37	48	0.22	Cloudy	52
5	42	33	38	1.58	Cloudy	0
6	43	31	37	0.05	Cloudy	23
7	43	27	35	0	Partly cloudy	65
8	40	25	32	0	Partly cloudy	98
9	42	21	32	0	Clear	100
10	53	22	38	0	Clear	100
11	67	37	52	0	Partly cloudy	79
12	47	24	36	0	Cloudy	14
13	41	22	32	0	Clear	98
14	35	22	28	0	Cloudy	11
15	36	24	30	0	Cloudy	1
16	51	22	36	0	Partly cloudy	75
17	57	39	48	0	Cloudy	17
18	72	41	56	0.67	Cloudy	49
19	73	55	64	1.01	Cloudy	12
20	76	50	63	0.41	Partly cloudy	37
21	54	43	48	0	Partly cloudy	50
22	65	40	52	0.36	Clear	99
23	57	38	48	0.16	Cloudy	68
24	55	33	44	0	Partly cloudy	91
25	46	33	40	0.42	Cloudy	0
26	40	34	37	0.02	Cloudy	1
27	53	31	42	0	Partly cloudy	68
28	53	30	42	0	Partly cloudy	61
29	49	41	45	0.05	Cloudy	0
30	54	41	48	0.23	Cloudy	11

Mean highest temperature	51.7
Mean lowest temperature	33.0
Mean temperature for month	42.4
Total precipitation for month	5.59
Weather	
Number days clear	4
Partly cloudy	10
Cloudy	16
With 0.01 or more of precipitation	14
Sunshine	
Number hours sunshine	184.1
Possible hours sunshine	402.5
Percentage of possible	46

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	....	....
1864	45.9	3.80
1865	47.4	2.32
1866	48.9	1.40
1867	48.2	2.19
1868	43.7	1.83
1869	45.7	3.42
1870	50.4	2.02
1871	49.8	2.97
1872	47.4	1.26
1873	43.2	3.88
1874	36.9	1.67
1875	41.1	0.61
1876	44.2	2.08
1877	46.2	4.14
1878	50.6	3.76
1879	44.8	1.25
1880	45.9	7.06
1881	45.6	1.73
1882	44.7	1.88
1883	43.5	1.90
1884	43.7	1.95
1885	43.6	2.47
1886	50.2	1.99
1887	45.4	0.90
1888	44.0	1.15
1889	46.6	2.02
1890	47.2	3.20
1891	47.4	1.74
1892	44.5	2.04
1893	43.5	4.81
1894	48.4	2.76
1895	48.6	0.67
1896	52.6	2.77
1897	44.6	2.74
1898	43.6	2.12
1899	49.8	1.23
1900	47.4	2.00
1901	46.4	2.16
1902	44.0	1.70
1903	43.0	4.40
1904	39.4	0.50
1905	44.6	1.49
1906	46.6	2.43
1907	37.8	2.81
1908	44.6	2.15
1909	42.8	5.96
1910	49.2	2.48
1911	44.3	2.11
1912	45.6	3.12
1913	45.9	3.10
1914	44.7	2.90
1915	51.6	1.00
1916	45.7	1.91
1917	42.4	5.59

BAROMETER—Mean, 30.00 inches; highest, 30.37 inches, on 4th; lowest, 29.36 inches, on 30th.

TEMPERATURE—Highest, 76°, on 20th; lowest, 21°, on 9th; greatest daily range, 31°, on 18th; least daily range, 6°, on 26th; normal for month, 45.6°; excess or deficiency this month, −3.2°; accumulated excess or deficiency since January 1st, −249°; average daily, same period, −2.1°; highest in 32 years, 88°; lowest, 10°.

PRECIPITATION (in inches)—Total amount, 5.59; normal, 2.54; excess or deficiency this month, +3.05; since January 1st, −1.73; greatest amount in any 24 hour period, 1.73, on 4th and 5th; total snowfall, 1.3 inches.

WIND—Prevailing direction, north; total movement, 5,436 miles; average hourly velocity, 7.6 miles; maximum velocity, 30; from the northwest, on 18th.

DATES OF—Auroras, 0; dense fog, 0; hail, 0; sleet, 0; thunderstorms, 18, 19, 20, 30; halos: solar, 4, 7, 10, 11, 16, 18, 23, 24,28. lunar, 0; frost: killing, 16, 27, 28.

DEWEY A. SEELEY,
Local Forecaster.

Monthly Meteorological Summary, Lansing, Michigan, May, 1917.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	51	37	44	0.11	Cloudy	0
2	51	31	41	0.01	Partly cloudy	61
3	59	30	44	0	Clear	99
4	47	33	40	0	Cloudy	28
5	45	36	40	0.04	Cloudy	0
6	52	39	46	0.10	Cloudy	43
7	59	35	47	0	Partly cloudy	72
8	56	36	46	0	Cloudy	37
9	55	32	44	0	Partly cloudy	68
10	62	33	48	0	Clear	85
11	53	35	44	0	Cloudy	60
12	49	39	44	0	Cloudy	0
13	61	41	51	0	Partly cloudy	77
14	71	37	54	0	Partly cloudy	99
15	71	44	58	0	Cloudy	51
16	76	51	64	0	Cloudy	65
17	73	49	61	0.01	Partly cloudy	63
18	81	56	68	0	Clear	100
19	83	57	70	0.01	Cloudy	70
20	64	46	55	0	Partly cloudy	73
21	46	39	42	0.86	Cloudy	0
22	42	33	38	0.83	Cloudy	0
23	44	33	38	0.03	Cloudy	5
24	52	37	44	0	Cloudy	27
25	65	37	51	0	Cloudy	87
26	61	43	52	0.39	Cloudy	10
27	54	44	49	0.90	Cloudy	24
28	61	41	51	0	Cloudy	35
29	71	41	56	0	Clear	100
30	70	47	58	0	Cloudy	24
31	72	59	66	0.08	Cloudy	15

Mean highest temperature	59.9
Mean lowest temperature	40.4
Mean temperature for month	50.2
Total precipitation for month	3.37
Weather	
Number days clear	4
Partly cloudy	7
Cloudy	20
With 0.01 or more of precipitation	12
Sunshine	
Number hours sunshine	216.7
Possible hours sunshine	454.7
Percentage of possible	48

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	....	....
1864	60.2	2.87
1865	57.6	1.77
1866	55.0	3.48
1867	61.1	3.80
1868	59.1	2.80
1869	56.0	2.05
1870	64.3	1.16
1871	61.4	1.97
1872	58.5	3.72
1873	56.9	3.05
1874	59.6	1.77
1875	60.8	4.46
1876	58.0	4.13
1877	58.2	2.23
1878	54.6	3.44
1879	58.8	2.45
1880	64.3	5.59
1881	65.2	2.11
1882	52.7	4.04
1883	52.8	5.66
1884	56.9	3.95
1885	55.8	2.30
1886	58.1	2.67
1887	64.3	2.42
1888	53.7	3.66
1889	57.4	3.61
1890	53.7	4.98
1891	55.7	1.63
1892	54.5	5.92
1893	54.4	2.86
1894	56.9	4.83
1895	61.8	2.06
1896	66.5	3.14
1897	55.8	3.29
1898	56.5	2.15
1899	58.8	3.59
1900	58.8	4.17
1901	55.2	2.42
1902	58.4	4.92
1903	59.5	2.63
1904	57.4	2.40
1905	56.7	5.17
1906	56.6	3.05
1907	51.2	2.22
1908	59.6	5.59
1909	55.8	2.44
1910	51.5	4.13
1911	63.5	2.67
1912	57.6	6.57
1913	56.2	2.22
1914	58.6	4.66
1915	51.5	2.74
1916	56.6	5.13
1917	50.2	3.37

BAROMETER—Mean, 29.92 inches; highest, 30.22 inches, on 7th; lowest, 29.27 inches, on 1st.

TEMPERATURE—Highest, 83°, on 19th; lowest, 30°, on 3rd; greatest daily range, 34°, on 14th; least daily range, 7°, on 21st; normal for month, 57.1°; excess or deficiency this month, −7.0°; accumulated excess or deficiency since January 1st, −464°: average daily, same period, −3.1°; highest in 32 years, 95°; lowest, 17°.

PRECIPITATION (in inches)—Total amount, 3.37; normal, 3.58; excess or deficiency this month, −0.21; since January 1st, +1.52; greatest amount in any 24 hour period, 1.29, on 26th and 27th; total snowfall, 0.0 inches.

WIND—Prevailing direction, northwest; total movement, 6,097 miles; average hourly velocity, 8.2 miles; maximum velocity, 29, from the southwest, on 1st.

DATES OF—Auroras, 0; dense fog, 0; hail, 26; sleet, 0; thunderstorms, 1, 17, 19, 21, 26; halos: solar, 3, 4, 29; lunar, 3; frost: killing, 3; heavy, 9, 10; light, 4, 14.

DEWEY A. SEELEY,
Local Forecaster.

Monthly Meteorological Summary, Lansing, Michigan, June, 1917.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	66	56	61	0	Cloudy	43
2	76	49	62	0.03	Cloudy	43
3	72	46	59	0	Clear	100
4	75	51	63	0	Partly cloudy	83
5	63	57	60	0.45	Cloudy	5
6	76	58	67	1.19	Partly cloudy	48
7	63	54	58	0.08	Cloudy	21
8	69	51	60	0	Partly cloudy	67
9	73	48	60	0	Cloudy	76
10	77	52	64	0	Partly cloudy	91
11	81	53	67	0	Clear	98
12	85	59	72	0	Clear	88
13	78	50	64	0.35	Cloudy	16
14	60	47	54	0	Cloudy	54
15	56	45	50	0.01	Cloudy	42
16	67	39	53	0	Clear	100
17	71	45	58	0	Cloudy	62
18	83	55	69	0	Partly cloudy	80
19	79	55	67	0.12	Cloudy	56
20	64	47	56	0	Cloudy	66
21	78	43	60	0	Cloudy	88
22	75	54	64	0.18	Cloudy	37
23	74	52	63	0.84	Cloudy	12
24	68	51	60	0	Partly cloudy	39
25	73	49	61	0.01	Partly cloudy	70
26	84	62	73	0	Partly cloudy	79
27	79	57	68	0	Cloudy	71
28	73	60	66	1.27	Cloudy	9
29	75	54	64	0.01	Partly cloudy	80
30	79	52	66	0	Partly cloudy	97
31	....	....	....	....	....	....

Mean highest temperature	73.1
Mean lowest temperature	51.7
Mean temperature for month	62.4
Total precipitation for month	4.54

WEATHER

Number days clear	4
Partly cloudy	10
Cloudy	16
With 0.01 or more of precipitation	12

SUNSHINE

Number hours sunshine	280.9
Possible hours sunshine	459.4
Percentage of possible	61

This month since 1863.

Year.	Mean temperature	Total precipitation.
1863	....	....
1864	67.6	3.88
1865	70.8	3.55
1866	66.6	5.37
1867	71.6	2.83
1868	68.5	3.55
1869	64.4	4.40
1870	70.9	7.27
1871	68.2	2.93
1872	71.8	3.45
1873	70.6	2.96
1874	70.6	5.07
1875	66.6	1.84
1876	68.1	4.34
1877	65.9	3.53
1878	64.1	3.15
1879	66.0	2.87
1880	67.6	5.04
1881	64.3	4.37
1882	66.5	5.57
1883	65.9	11.35
1884	68.9	2.83
1885	64.7	6.01
1886	65.7	1.92
1887	68.5	2.47
1888	67.9	2.51
1889	62.8	3.42
1890	70.3	3.92
1891	67.4	2.55
1892	67.7	4.33
1893	66.6	4.85
1894	71.4	1.30
1895	71.4	1.01
1896	69.9	2.60
1897	64.2	2.57
1898	67.6	4.91
1899	68.2	1.15
1900	65.2	2.57
1901	68.0	3.57
1902	61.8	7.28
1903	62.0	6.28
1904	65.6	2.49
1905	66.2	7.47
1906	67.1	4.61
1907	65.0	2.37
1908	70.0	1.23
1909	66.7	2.86
1910	64.9	1.95
1911	68.0	3.77
1912	63.1	0.97
1913	67.6	1.01
1914	66.0	4.11
1915	61.0	3.96
1916	61.4	5.39
1917	62.4	4.54

BAROMETER—Mean, 30.01 inches; highest, 30.31 inches, on 17th; lowest, 29.58 inches, on 6th.

TEMPERATURE—Highest, 85°, on 12th; lowest, 39°, on 16th; greatest daily range, 35°, on 21st; least daily range, 6°, on 5th; normal for month, 67.2°; excess or deficiency this month, −4.8°; accumulated excess or deficiency since January 1st, −610°; average daily, same period, −3.4°; highest in 32 years, 99°, lowest, 34°.

PRECIPITATION (in inches)—Total amount, 4.54; normal, 3.40; excess or deficiency this month, +1.14; since January 1st, +2.66; greatest amount in any 24 hour period, 1.56, on 5th and 6th; total snowfall, 0.0 inches.

WIND—Prevailing direction, southwest; total movement, 4,213 miles; average hourly velocity, 5.8 miles; maximum velocity, 23, from the southwest, on 2nd.

DATES OF—Auroras, 0; dense fog, 0; hail, 0; sleet, 0; thunderstorms, 5, 6, 13, 19, 23, 25, 26, 28; halos: solar, 9, 30; lunar, 0; frost: killing, 0; heavy, 0; light, 0.

DEWEY A. SEELEY,
Local Forecaster.

REPORT OF DIVISION OF EXTENSION WORK.

President F. S. Kedzie:

Dear Sir:—The Extension Service of the College for the year ending June 30, 1917, was carried on under the same sixteen projects, with the exception of No. 10, as were reported last year, as follows:

1. Administration.
2. County Agricultural Agents.
3. Home Economics.
4. Extension Schools.
5. Boys' and Girls' Clubs.
6. Farm Crops.
7. Live Stock.
8. Horticulture.
9. Potatoes and Vegetables.
10. Control of Muck Crop Diseases.*
11. Farm Management Demonstrations.
12. Control of Insect Pests.
13. Household Engineering.
14. Forestry.
15. Markets.
16. Farmers' Institutes.

The work conducted under each of these projects is given in the reports of the various leaders which are appended hereto.

EXTENSION BULLETINS PUBLISHED DURING FISCAL YEAR.

	Title.	Author.	Edition.	Pages.
Ext. Course Notes No. 10	Dairy cattle feeding	J. A. Waldron	10,000	16
Ext. Course Notes No. 11	Food values	Dept. of Domestic Science	10,000	7
Ext. Course Notes No. 12	Milk	Dept. of Domestic Science	10,000	4
Ext. Course Notes No. 13	Eggs	Dept. of Domestic Science	10,000	7
Ext. Course Notes No. 14	Market classes and grades of meat	Dept. of Domestic Science	10,000	14
Ext. Course Notes No. 15	Vegetable foods	Dept. of Domestic Science	10,000	21
Ext. Course Notes No. 16	Rules for planning the family dietary	Dept. of Domestic Science	10,000	11
Ext. Bull. No. 1 (Revised)	Inoculation with nodule forming bacteria	Ward Giltner	5,000	4
Ext. Bull. No. 6	Some bean pointers	J. F. Cox	10,000	8
Ext. Bull. No. 7	Suggestions for growing potatoes	C. W. Waid	5,000	6
Club Bulletin No. 10	Home canning by the one-period cold pack method	Anna Bryant Cowles	15,000	10

RESIGNATIONS AND APPOINTMENTS OCCURRING DURING FISCAL YEAR

JULY 1, 1916, TO JULY 1, 1917.

Resignations

J. F. Zimmer..........County Agent..................January 1, '17
J. Allen Petrie........Ext. Spec. in Horticulture.......April 15, '17
C. P. Reed.............Farm Management Demonstrator..May 15, '17
I. K. Maystead........Ext. Spec. in Farm Crops.........May 15, '17
Paulina E. Raven......Home Economics................June 29, '17

*Established in May, '17.

Appointments		
C. A. Spaulding	Asst. to State Leader, Boys' and Girls' Clubs	July 1, '16
J. A. Petrie	Horticulture	July 1, '16
Edna V. Smith	Home Economics	July 1, '16
E. C. Mandenberg	Forestry	July 1, '16

County Agents	County	
Frank Sandhammer	Manistee	July 1, '16
E. B. Hill	Menominee	July 1, '16
E. G. Amos	Schoolcraft	July 1, '16
Geo. E. Piper	Wexford	January 10, '17
H. L. Barnum	Missaukee	March 6, '17
Carl M. Kidman	Presque Isle	April 20, '17
Benj. P. Pattison	Delta	May 15, '17
Orestes I. Gregg	Wayne	June 1, '17
E. L. Kunze	Chippewa	June 11, '17

STATISTICAL SUMMARY.

*Lectures	1,841
Attendance	44,194
Demonstrations	311
Attendance	6,594
Canning Demonstrations	314
Attendance	17,084
Extension Schools	92
Attendance	5,936
Farm Visits	1,537
Farm Management Account books summarized	190
Account books started	932
Breeders' Associations organized	15
Cow Testing Associations	15
Fair (judging demonstrations)	22
Boys' and Girls' Clubs organized	682
Counties, Boys' and Girls' Clubs organized	61
Club members	27,654
Lectures by others than Extension staff	176
Attendance	56,661
Markets: associations organized	15
associations re-organized	8

EMERGENCY FOOD PRODUCTION.

Immediately following the declaration of a state of war with Germany, the importance of increasing food production was made a great issue by President Wilson. The success of any effort seemed to depend upon giving assistance along three lines, viz., labor, credit and seed. Plans to give material assistance along these lines had already been made for the 30 counties employing Federal and State County Agricultural Agents. In order that all counties could be served alike, a request was made to the War Preparedness Board for funds to employ 38

*For summary county agents' lectures and demonstrations, see Report No. 2, County Agents.

emergency agents for May 1st to October 31st. This request was granted and the agents were employed to act as joint agents of the College and the Food Preparedness Board. The following men were employed as Emergency Agricultural Agents.

County.	Name.	Address.
Alger	A. L. Olsen	Munising
Alcona, Iosco	R. E. Prescott	Lincoln
Antrim, Otsego, Montmorency	R. D. Bailey	Gaylord
Barry	R. G. Brumm	Nashville
Bay, Arenac	R. D. Harrison, Jr.	Bay City
Cass	W. D. Jones	Cassopolis
Calhoun	E. B. More	Marshall
Charlevoix	George A. Kilborn	Petoskey
Clare	W. J. Kennedy	Clare
Clinton	O. C. Hollister	Laingsburg
Eaton	Fred Curtiss	Charlotte
Genesee	J. F. Rieman	Flint, City Hall
Grand Traverse, Kalkaska	M. E. Duckles	Traverse City
Gladwin	U. R. Reynolds	Gladwin
Gratiot	C. J. Chambers	Ithaca
Hillsdale	Geo. B. Smith	Addison
Huron	L. L. McCarty	Bad Axe
Ingham	Frank Seeley	Mason
Ionia	Arthur P. Loomis	Ionia, R. F. D. No. 3
Isabella	Stephen S. Fall	Mt. Pleasant
Jackson	E. C. Fowler	Jackson, Court House
Lapeer	John W. Scully	Almont
Leelanau, Benzie	A. W. Mebert	Suttons Bay
Livingston	H. W. Norton	Howell
Macomb	R. G. Potts	Washington
Mackinac, Luce	M. A. Leach	Newberry
Mecosta	B. J. Ford	Big Rapids
Midland	H. W. Hock	Midland
Monroe	J. B. Winslow	Temperance
Montcalm	Edwin D. Greenhoe	Sheridan
Oakland	Harry McCracken	Farmington
Oceana	Bernie Beach	Hart
Osceola, Lake	C. L. Rose	Evart
Roscommon, Crawford, Ogemaw and Oscoda	W. F. Johnston	Roscommon
Sanilac	Grant Smith	Lexington
Shiawassee	A. B. Cook	Owosso
Tuscola	Alex MacVittie	Caro
Washtenaw	W. E. Underdown	Ann Arbor

From May 1st to June 30th these agents gave their time to securing seed, labor and credit where such needs were found. A complete report of their work will be made at the end of their term of appointment, October 31st, 1917.

A special publicity office was established April 1st, for the purpose of

placing in the hands of all newspapers of the state timely copy on food production lines. Mr. Earl Traugmar was employed to supervise the work and secure the cooperation of the press of the state. Practically all of the news and farm papers have supported the movement by giving liberally of space, using from one to two columns of agricultural matter each issue.

Very truly yours,
R. J. BALDWIN,
Extension Director.

East Lansing, Mich., June 30, 1917.

REPORT OF EXTENSION WORK IN HOME ECONOMICS.

BY EDNA V. SMITH.

The efforts during the year have been mainly toward the problems of preserving foods, and textiles. These lines were being made major features throughout the year and as war conditions approached and became a reality, full time was given to them. Canning by the one period cold-pack process has been demonstrated in 120 places and bulletins have been distributed through county agents, schools, women's clubs, granges, farmers' clubs, and other organizations until it is safe to say that any housewife in Michigan who has desired to can has had an opporunity to learn something of the method. Drying perishable fruits and vegetables has been considered important and demonstrations and lectures have been given wherever interest has been found.

The conserving of energy on the part of the home managers has also been given much attention through instruction in systematizing work and using labor saving equipment. This will continue to be of great importance because of the increasing scarcity of labor during the war.

The elimination of waste from the daily operations of the kitchen has been made a public issue through newspapers, posters and lectures and indications of results are found in the reports of garbage collectors from the larger cities to the effect that there has been a noticeable decrease in food products thrown into garbage.

The impossibility of the present extension staff meeting all calls for food demonstrations became apparent soon after the war program started and volunteer workers were called for. A training school for such workers was held at the College during the last week in June and was attended by over one hundred women who had had at least two years home economics training. Twelve thrift lessons were prepared by the Domestic Science department and these have been offered to thrift clubs which are being rapidly organized and placed in charge of some local leader. To bring the application of these thrift lessons pointedly to the attention of each individual a pledge card has been issued to be signed by the housewife and hung in the kitchen. The substance of the card is given below.

AS MY CONTRIBUTION TO MY COUNTRY IN ITS NEED, I PROMISE:

To Take A Vital Part in National Food Conservation. "To Make Saving Rather Than Spending My Social Standard," To Save Food:

1. By Careful Selection and Buying:
   1—Go to market myself as far as practicable.
   2—Buy food in season.
   3—Avoid foods high in price and low in nutritive value.
   4—Substitute cheap foods for expensive foods of same nutritive value.
   5—Conserve protein or tissue building foods by wider use of skimmed milk, sour milk, cottage cheese, etc.
   6—Order deliveries but once a day.

2. By Correct Cooking and Serving:
   1—Avoid cooking larger quantity than is needed.
   2—Use left-overs.
   3—Cook vegetables in jackets.
   4—Use water in which vegetables and meats are cooked.
   5—Use fireless cooker when possible.
   6—Avoid giving too large servings.
   7—Place carefully balanced ration on table for family.

3. By Cooperating with Others.
   To simplify refreshments at social gatherings.

4. By Canning and Drying
   Perishable vegetables and fruits.

Name..............................

SUMMARY OF HOME ECONOMICS EXTENSION WORK.

	No.	Attendance
Canning demonstrations	120	5,155
Miscellaneous demonstrations	60	2,638
Lecture meetings	112	9,519
Extension Schools	35	2,205
Total attendance		19,517

East Lansing, Mich., June 30, 1917.

REPORT OF COUNTY AGRICULTURAL AGENT WORK IN MICHIGAN FOR THE FISCAL YEAR ENDING JUNE 30, 1917.

BY EBEN MUMFORD, STATE LEADER.

INTRODUCTION.

Since January, 1916, a report of County Agricultural Agent work in Michigan has been issued each month. These reports have summarized the progress and results of the principal activities of the agents and form the basis of this annual report. The monthly reports are based upon the weekly reports which in turn give a report of the field and office work for each day. The monthly reports summarize the work under the leading projects and also give a statistical statement of the office and field work. The order used in the monthly reports, in describing the progress made in the various projects has been followed in this annual report, and a statistical summary of the office and field work for the year, as far as it has been possible to state the results statistically, included.

At the close of this fiscal year there were thirty-one counties having County Agricultural Agents under the regular Farm Bureau system, where the cooperating parties are the United States Department of Agriculture, the Michigan Agricultural College and the county organization. Five counties were added this year as noted in the chronological statement of the development of the work. There has been but one change in the personnel of the County Agents. Mr. J. F. Zimmer, County Agent for Wexford county, resigned December 30, 1916, and Mr. George E. Piper was selected to take the place.

There has been a considerable development in the employment of assistants to County Agents. The demands of the work soon become too numerous and too varied for one man to meet and in all counties where the work has become established the time of one or more assistants could be used to great advantage. In Kent county by June 1 there were five assistants: Mr. C. J. Seidel and Mr. Floyd Smith, Assistant County Agents; Mr. L. S. Markley, Assistant in Boys' and Girls' Club work; Mr. William Murphy, assistant in Gardening; and Miss Emily Castle, canning supervisor. In Marquette county Mr. H. C. Rather was made assistant in club work; in Ottawa county, Mr. William Van Buskirk, Assistant County Agent and Mr. Charles Morrice assistant in club work. In other counties assistants in club work have been employed for the summer and in many counties assistants have been appointed to take charge of the canning demonstrations.

CHRONOLOGICAL STATEMENT OF THE DEVELOPMENT OF COUNTY AGRICULTURAL AGENT WORK.

County.	Agricultural agent.	Date of beginning.	Address.
Alpena	H. G. Smith	July 1, 1912	Alpena.
	David Woodman	Mar. 20, 1916	
Iron	R. G. Hoopingarner	Sept. 1, 1912	Crystal Falls.
Kent	J. H. Skinner	Sept. 16, 1912	Grand Rapids.
	H. G. Smith	Jan. 1, 1916	
Kalamazoo	Jason Woodman	Nov. 1, 1912	Kalamazoo.
Allegan	C. B. Cook	Mar. 1, 1913	Allegan.
	Alfred Bentall	April 20, 1916	
St. Clair	L. V. Crandall	Mar. 1, 1913	Port Huron.
	Clark L. Brody	April 1, 1915	
Branch	J. W. Chapin	April 1, 1913	Coldwater.
	C. L. Nash	July 1, 1916	
Saginaw	Earl P. Robinson	April 1, 1913	Saginaw.
Houghton	L. M. Geismar	June 1, 1913	Houghton.
Newaygo	H. B. Blandford	June 10, 1913	Fremont.
Gogebic	J. F. Kadonsky	July 1, 1914	Ironwood.
Wexford	J. F. Zimmer	Oct. 1, 1914	Cadillac.
	G. E. Piper	Jan. 10, 1917	
St. Joseph	J. M. Wendt	Dec. 15, 1914	Centreville.
Marquette	L. R. Walker	July 1, 1915	Marquette.
Dickinson	C. V. Ballard	July 1, 1915	Iron Mountain.
Lenawee	C. L. Coffeen	Aug. 23, 1915	Adrian.
Ontonagon	R. G. Carr	Oct. 10, 1915	Ontonagon.
Cheboygan	C. H. Knopf	Dec. 1, 1915	Cheboygan.
Ottawa	D. L. Hagerman	Jan. 1, 1916	Grand Haven.
Mason	R. V. Tanner	Feb. 16, 1916	Scottville.
Muskegon	R. L. Olds	Mar. 1, 1916	Muskegon.
Van Buren	T. A. Farrand	Mar. 1, 1916	Paw Paw.
Berrien	H. J. Lurkins	May 1, 1916	Benton Harbor.
Manistee	Frank Sandhammer	July 1, 1916	Manistee.
Menominee	E. B. Hill	July 1, 1916	Menominee.
Schoolcraft	E. G. Amos	July 1, 1916	Manistique.
Missaukee	H. L. Barnum	Mar. 6, 1917	Lake City.
Presque Isle	C. M. Kidman	April 20, 1917	Onaway.
Delta	B. P. Pattison	May 15, 1917	Escanaba.
Wayne	O. I. Gregg	June 1, 1917	Dearborn.
Chippewa	E. L. Kunze	June 11, 1917	Sault Ste. Marie.

Through appropriations by the Boards of Supervisors three more counties, Genesee, Luce and Alger, have raised their share of the funds for starting regular County Agent work and each will be in position to employ an Agricultural Agent as soon as funds are available from the College and the U. S. Department of Agriculture. In Tuscola county forty men pledged fifty dollars each as a guarantee fund for starting the work there. Mr. Alexander MacVittie was chosen as Agricultural Agent, to begin work August 15, 1917. Farm Bureaus have been formed in Isabella, Luce and Washtenaw counties and plans are being made for starting County Agent work. There are other counties in which the County Agent movement has been explained at farmers' meetings and in which steps have been taken toward strengthening the sentiment for the work.

FINANCING THE WORK.

The plan for financing the work has been essentially the same as that outlined in last year's report. In all of the counties except four, the larger part of the county's share of the funds is now appropriated by the Board of Supervisors. In three of these four counties the work was started by membership fees and subscriptions, and in the other, one-half

of the funds was raised in this way and the other half was appropriated by the Board of Supervisors. However, the indications now are that in all four of these counties the larger portion of the county's share of the funds will soon be appropriated through the county government. Farm Bureau membership fees and subscriptions continue to form an important supplemental fund and are particularly valuable in securing a personal interest in the work.

PLANNING OF WORK AT THE ANNUAL CONFERENCE.

One of the most important features of the year's work was the Conference held at the College November 20-24, 1916. The main purpose of this Conference was the formulation of plans and methods for 1917. In order that there might be as much time as possible for the consideration of these plans and methods, there were appointed by the State Leader, two weeks in advance of the Conference, twenty-two committees composed of members of the College faculty, Extension Specialists and County Agricultural Agents, to outline the different projects for discussion. As a result much valuable work had been done before the Conference assembled.

There were eleven sessions of the Conference, beginning Monday afternoon and closing Friday noon. The first day was set apart for the meetings of the committees, especially of those whose reports came early in the week. The results of this plan were very satisfactory. The reports of the committees brought the problems and plans before the Conference in a clearly stated and definite form for discussion. There was a splendid spirit of cooperation throughout the Conference and everybody worked constantly toward the one end of securing the most practical plans possible for another year.

Twenty-five projects were outlined and adopted. Each of these gives a statement of the objects of the project and the methods of procedure for putting it into operation in the county, including suggestions for demonstration work and for securing definite data and, so far as possible, measured results. A few selected references were included with each project, and copies of all the projects were sent to the County Agents, members of the faculty, Extension Specialists and Farm Bureau officers. The subjects concerning which projects were adopted are as follows: Organization, Soils, Commercial Fertilizers, Drainage, Distribution of Pure Seed, Legumes, Potatoes, Horticulture, Entomology, Control of Plant Diseases, Live Stock Program for Michigan, Live Stock Breeders' Associations, Cow Testing Associations, Control of Animal Diseases, Poultry Demonstrations, Feeding Demonstrations and Records of Production, Farm Management, Household Engineering, Boys' and Girls' Clubs, Relation of the Teachers of Agriculture in High Schools to County Agricultural Agent Work, Relation of County Agents to Cooperative Marketing, Exhibits and Fairs, Relation of County Agents to Federal Farm Loan Act, Forestry, and Home Economics.

RELATION OF COUNTY AGRICULTURAL AGENT WORK TO THE OTHER PHASES OF THE EXTENSION SYSTEM.

The County Agricultural Agent work is not a one-man movement but is a system by which the people of the county through a County Farm Bureau with its affiliated community groups formulate an agricultural

program and select certain definite and timely projects upon which to concentrate attention for the year or for such periods of time as may be necessary to solve community and county problems, or to secure valuable data or results. In the formulation of such a program and in the solution of their agricultural problems the people of the county cooperate through their Agricultural Agent with the College and the United States Department of Agriculture. This cooperative relationship recognizes the local, state and national aspects of agriculture, and greatly increases the possibilities of agricultural advancement. The County Agent becomes a specialist on local and county conditions and needs, and this, with his acquaintance with the people and their organizations, makes it possible for him to direct the extension work of the county, effectively. Leadership and cooperation are being developed within the counties, and College and department specialists are being brought to the counties to assist. Such assistance is used where most needed, and with the greatest advantage and economy of time, both to the people of the county and to the College and department.

The increase in the number of Extension specialists has made possible a still larger amount of cooperative work this year and the number of requests for this help continues to grow. The following table gives the number of visits made by the specialists to the counties having agents; the total for the year was 716:

County.	Months reported.	No. of visits.	County.	Months reported.	No. of visits.
Allegan	12	26	Marquette	12	19
Alpena	12	7	Mason	12	27
Berrien	12	48	Menominee	12	8
Branch	12	18	Muskegon	12	31
Cheboygan	12	13	Newaygo	12	27
Chippewa	2	1	Ontonagon	12	4
Delta	2	2	Ottawa	12	28
Dickinson	12	7	Presque Isle	1	2
Gogebic	12	5	Saginaw	12	42
Houghton	12	8	St. Clair	12	38
Iron	11	13	St. Joseph	12	36
Kalamazoo	12	44	Schoolcraft	12	7
Kent	12	145	Van Buren	12	46
Lenawee	12	29	Wayne	1	6
Manistee	12	20	Wexford	12	9

STATISTICAL SUMMARY OF OFFICE AND FIELD WORK.

The tabular statement included in this section gives a summary of some of the important phases of office and field work. The office work requires an average of about 35% of the agent's time. This time is needed for planning the work, answering personal and telephone calls, for tabulation of data, preparation of reports and for correspondence. A total of 16,301 farmers called on the agents at their offices for information on various subjects relating to the farm; in the 26 counties having the work for the full year the average for each county was 522 calls.

Press articles form one of the best means of forwarding the work, by keeping before the people the activities of the Farm Bureau each week, calling attention to the more urgent or timely community and county needs, or giving warning of the appearance of transmissible animal diseases or of the presence of insect and fungous troubles. In almost all in-

stances the papers of the counties have cooperated in every way possible in the Farm Bureau work. The extent of this cooperation is seen in the fact that 1405 different articles were written this year; as some of these articles appeared in as many as nine papers in some of the counties the circulation was much more extensive than is represented by these figures.

In field work there was a total of 13,965 farm visits averaging 612 for each agent. However, to reach the largest number of farmers it is necessary to work through groups and by communities and for this purpose the demonstrations conducted on some of the farms of the community and planned to benefit the group, constitute one of the best methods of field work. A study of the tables relating to demonstrations will give an idea of the magnitude of this kind of work. The demonstration has its greatest value when visited by a large number of farmers and this is made possible now on a county-wide basis or even an inter-county basis by the automobile tour. There were 479 meetings held this year at demonstrations, with a total attendance of 13,146. The term "other meetings" refers to all assemblies of farmers in relation to the work except the demonstration meetings, and includes meetings for planning work in the county or the communities, meetings of the various organizations and associations for forwarding specific agricultural enterprises, such as the crop associations, live stock organizations, farm loan associations, institutes and extension schools. There were 2,952 of these with an attendance of 168,673.

STATISTICAL SUMMARY—OFFICE.

County.	Months reported.	Days in office.	Calls on agent.	Telephone calls.	Letters written.	Copies of circular letters mailed.	Articles in local press.	Bulletins distributed.
Allegan	12	103¾	529	278	1,524	5,215	44	427
Alpena	12	124½	589	888	1,001	109	12	229
Berrien	12	41¾	762	1,157	1,924	4,834	47	5,211
Branch	12	113½	350	472	1,006	5,281	65	416
Cheboygan	12	111¾	499	706	1,102	1,653	97	2,710
Chippewa	2	10	98	14	27	....	21	93
Delta	2	22½	57	47	190	....	10	50
Dickinson	12	101½	248	415	286	1,080	30	252
Gogebic	12	90¾	505	684	1,188	31	43	708
Houghton	12	50½	285	1,127	1,191	1,514	53	518
Iron	11	69	229	230	884	2,899	42	1,038
Kalamazoo	12	154	634	....	757	1	7	....
Kent	12	154½	607	1,162	1,266	27,136	2	8,000
Lenawee	12	67¾	1,822	3,685	1,957	1,496	38	346
Manistee	12	83	1,034	1,713	3,021	4,867	120	1,804
Marquette	12	108¾	319	510	909	3,552	12	1,843
Mason	12	91½	830	1,409	1,495	3,262	44	1,105
Menominee	12	128¾	217	234	1,279	3,969	80	3,400
Missaukee	4	54½	204	72	299	339	25	199
Muskegon	12	73½	394	572	436	450	7	185
Newaygo	12	102½	1,027	1,226	1,706	12,001	9	12
Ontonagon	12	106	182	296	921	2,059	49	103
Ottawa	12	107¾	487	696	1,776	9,654	39	1,549
Presque Isle	1	7	16	18	32	14	9	22
Saginaw	12	141½	295	669	881	3,848	38	2,739
St. Clair	12	126	1,150	1,022	2,071	2,990	142	3,357
St. Joseph	12	135¾	535	925	1,148	5,192	153	162
Schoolcraft	12	136¼	756	562	528	1,691	37	305
Van Buren	12	89	712	69	1,903	7,960	51	602
Wayne	1	14	1	....	103	50	1	....
Wexford:								
1st 6 months	6	39½	304	320	664	129	31	125
2nd 6 months	6	69¾	617	641	1,043	2,746	47	250
Totals	....	2,833¼	16,304	21,819	34,508	11,622	1,405	37,760

STATISTICAL SUMMARY—FIELD.

County.	Months reported.	Days in field.	Farm visits.	Demonstrations.				Other meetings.	Attendance.
				Started.	Visited.	Meetings at.	Attendance at meetings.		
Allegan	12	203¼	683	48	69	20	700	164	10,020
Alpena	12	168½	458	28	17	11	289	57	2,241
Berrien	12	250½	855	58	28	21	768	279	15,773
Branch	12	187	675	34	35	23	395	119	7,259
Cheboygan	12	178¼	526	27	11	32	546	75	2,236
Chippewa	2	20	58	3	......	......	......	23	637
Delta	2	17½	114	1	2	......	......	3	30
Dickinson	12	188½	470	9	8	19	207	62	1,871
Gogebic	12	204½	630	291	375	16	845	26	1,900
Houghton	12	255½	647	5	61	41	494	34	1,507
Iron	11	171	587	73	30	26	863	78	2,561
Kalamazoo	12	127½	391	......	......	......	25	56	3,691
Kent	12	141½	109	23	6	15	319	166	9,383
Lenawee	12	242¾	508	1	10	3	92	78	9,207
Manistee	12	222	643	38	159	14	582	170	9,516
Marquette	12	190¾	410	5	26	13	125	119	6,392
Mason	12	206½	492	49	12	27	347	187	7,792
Menominee	12	179¾	710	27	3	16	400	91	4,193
Missaukee	4	34	138	11	5	......	......	36	1,215
Muskegon	12	224½	478	142	119	35	354	79	3,971
Newaygo	12	191½	348	23	86	21	474	96	6,457
Ontonagon	12	199	498	......	......	25	972	102	3,712
Ottawa	12	191¾	335	28	39	30	1,990	170	10,483
Presque Isle	1	17	58	5	2	......	......	1	6
Saginaw	12	151	374	14	66	12	525	122	10,207
St. Clair	12	173	355	47	52	17	748	127	9,371
St. Joseph	12	168½	439	156	121	14	180	118	6,278
Schoolcraft	12	162¼	648	4	5	11	210	120	4,445
Van Buren	12	211½	724	7	57	11	566	142	9,686
Wayne	1	10	2	......	......	......	......	10	514
Wexford:									
1st 6 months	6	99½	443	15	23	6	130	12	4,402
2nd 6 months	6	70¾	159	26	......	......	......	30	1,708
Totals		5,059½	13,965	928	1,427	479	13,146	2,952	168,673

STATISTICAL SUMMARY

From July 1, 1916, to June 30, 1917.

	July.	August.	Sept.	Oct.	Nov.	Dec.
Number of Agents reporting	26	26	25	26	26	26
OFFICE.						
Days in office	189	135½	137½	198¼	286¾	268¼
Calls on Agent:						
Personal	797	875	845	1,021	698	824
Telephone	1,157	1,090	1,091	1,439	895	1,120
Articles published in local press	127	91	86	107	73	84
Letters written	2,478	2,008	1,938	2,645	1,840	2,203
Circular letters mailed	3,489	5,011	5,551	6,337	3,386	4,731
Bulletins distributed	1,774	991	6,402	648	335	599
FIELD.						
Days in field	551½	434½	452¾	569¼	272	273½
Farm visits made	2,429	1,783	1,330	1,889	670	518
Demonstrations:						
a. Started (5 months)	....	102	115	85	27	45
b. Visited	338	170	124	144	14	27
c. Meetings held at	62	75	16	33	9	1
d. Attendance at meetings	3,986	1,030	634	284	69	83
Other meetings held	103	95	110	171	114	207
Attendance	1,296	13,372	6,588	6,293	5,404	8,312

	Jan.	Feb.	March.	April.	May.	June
Number of Agents reporting	26	26	27	27	29	31
OFFICE.						
Days in office	309¾	246	302¼	286	247	228
Calls on Agent:						
Personal	1,214	1,179	1,397	2,785	2,627	2,122
Telephone	1,408	1,548	1,452	3,460	3,842	3,357
Articles published in local press	151	118	97	182	136	153
Letters written	2,916	2,786	3,143	4,815	3,950	3,786
Circular letters mailed	5,227	4,480	18,646	23,027	16,861	13,444
Bulletins distributed	1,361	1,372	6,568	4,885	10,815	2,010
FIELD.						
Days in field	429	362	314	508½	399½	493
Farm visits made	435	272	408	1,073	1,438	1,765
Demonstrations:						
a. Started (6 months)	44	59	92	258	178	216
b. Visited	28	33	41	66	178	264
c. Meetings held at	13	32	41	102	44	51
d. Attendance at meetings	384	1,206	1,218	1,102	384	2,697
Other meetings held	577	393	227	492	248	215
Attendance	45,866	25,221	9,980	26,684	9,957	10,121

ORGANIZATION.

The progress in organization has been through the channels indicated in the report of last year, with emphasis on the development of community groups and committees through which the agricultural program and the various county and community projects can be carried on. In other words, the community is taken as the natural unit of organization. The organization of the community for Farm Bureau work assumes several different forms; in many communities there are Granges, Farmers' Clubs or Gleaner Arbors; in these same communities there may be also one or more organizations for forwarding specific agricultural enterprises such as cow testing or community breeders' associations, the various crop organizations, for potatoes, beans, cabbage, celery, or pedigreed seeds; farm loan associations; and the organizations for marketing the differ-

ent farm products. For example, in 1916 the agents in the 26 counties were working through approximately 480 organizations, with an estimated membership of 27,548. However, some of the farmers in these communities may not belong to any of these organizations and in some communities there may be no organizations. The problem, therefore, is to devise for each community the type of organization which will be best adapted to its needs. The one fundamental requirement for all communities is to provide a working organization that will be representative of every agricultural interest of the community and also representative of all the farmers. As the Farm Bureau work is mainly supported by public funds and represents the nation, the state, the county and the community, it forms the basis for the type of organization which can coordinate and federate the activities of other agricultural organizations and also include in its membership all farmers who are interested, whether already members of some organizations or not.

A further development of the work this year has been the beginning of the organization of the communities by having each school district represented by one of its leading farmers. The Farm Bureau program is largely educational in character and should be closely related to that of the public school system. Moreover, the school district constitutes a definite territorial unit, small enough for personal acquaintance; by virtue of these characteristics it forms a good basis for taking a census or for making an agricultural survey in the most expeditious manner.

A very important project in organization begun this year is the formation of national farm loan associations. Although this work was not started until late in the year, the agents have assisted in the formation of 29 associations. One session of the annual County Agent Conference was given to the discussion of this project and a special meeting of the agents of the Upper Peninsula was held in May to consider the specific problems that had arisen in the organization work and that were more or less peculiar to that section of the state. The discussions of this conference were led by Mr. B. F. Faast, Vice President of the St. Paul Federal Land Bank. One of the most significant features of the National Farm Loan Association for Farm Bureau work as brought out by Mr. Faast is the possibility of such associations becoming the nuclei of very strong and efficient community centers. They bring men into close business relationships, lead them to assume mutual responsibilities of a fundamental character, help to establish ownership in land and provide for the development of the farm business, and these are essentials in the welfare of all rural institutions.

SOILS.

Problems: In all of the counties soil problems in some of their phases constitute one of the major projects and considerable progress has been made this year in interesting larger numbers of farmers in the work relating to soils, particularly through demonstrations.

Soil Surveys, Analyses and Tests: The surveys begun last year in cooperation with the Department of Soils have been continued. Surveys have been made this year in five counties: they are Berrien, Branch, Manistee, Mason and Newaygo. These surveys of the different types of soils of the counties and the analyses that are being made by the Department of Soils are very valuable to the agents and are receiving much attention on the part of the farmers. The results of the survey made in St.

Joseph county last year were presented at the institutes, extension schools and other community meetings; these results have been helpful in planning demonstrations and have led to an increased use of lime and fertilizer.

Use of Fertilizers: Through tests and demonstrations in the use of fertilizers on the different soil types of the counties attention is being called to the plant foods needed and to the most economical methods of maintaining soil fertility. Perhaps at this stage in the use of fertilizers the largest service the agents are able to perform is through well conducted demonstrations showing the most economical methods of securing the necessary plant food for the different soils.

Twenty counties report fertilizer demonstrations. Particularly good results have been obtained from the demonstrations in the use of phosphates. As a result of these demonstrations there has been a big increase in the use of acid phosphate. In Muskegon county last year one car of acid phosphate was used in demonstrations on wheat, alfalfa and oats and as a result of these demonstrations and explanations of them made at meetings, seven cars of acid phosphate were used by the farmers this year on spring seeding; in Ottawa county several different communities have been purchasing acid phosphate in car lots this season, one community alone using 200 tons; in Mason county 38 demonstrations in the use of acid phosphate are being carried on. Among the other counties reporting excellent results from the use of acid phosphate, particularly on wheat, are Allegan, Berrien, Branch, Kalamazoo, Kent, Mason and Newaygo. In cooperation with the Soils department tests conducted on the Van Buren County Farm showed excellent results from both acid and rock phosphate, doubling the yield of oats. At the Kent County Farm similar cooperative experiments showed that 400 pounds of acid phosphate increased the yield of potatoes 60 bushels per acre over the untreated plots.

Correcting Acidity: Samples of soil from more than a thousand farms have been tested for acidity, marl beds have been located, a marl pumping demonstration was given in Van Buren county in cooperation with the Farm Mechanics department, lime campaigns have been conducted and the use of lime and marl is rapidly increasing. The practice has now become so extensive that it is difficult to get complete data on the number of tons used in each county. An estimate based upon the figures available would indicate that more than 50,000 tons of lime were applied on the counties this year.

Use of Legumes: The increase in the use of lime and marl is in close relation to the increase in the use of legumes for soil building demonstrations of the value of the diffierent legumes and of the best methods of growing and using them, are carried on extensively in nearly all of the counties.

Alfalfa: Twenty-one counties report a large amount of work on alfalfa, including tests for acidity; helping to secure the best and most economical forms of lime for the different localities; testing the value of fertilizers; finding sources of the best seed and particularly of the hardier strains; distributing cultures; conducting inoculating demonstrations; advising on the preparation of the soil and on the time and methods of making hay; on removing June grass; and on the value of alfalfa for pasture or for hay. In some of the counties the successful

methods of growing alfalfa are becoming more generally known and the crop is being grown more extensively.

Sweet Clover: Eight counties report assistance given in the growing of sweet clover. Where soil is well supplied with lime and the seed is inoculated, good results are reported. The demonstrations include the use of lime, the treating of seed, use of the clover as a green manure crop, for pasture, hay and seed.

Vetch: Ten counties report demonstrations of the growing of vetch for seed, hay or green manure. In some instances on the lighter soils vetch and rye are being tried as a preparation for the growing of alfalfa. The agents have assisted in getting seed and cultures, and in inoculating the seed. On some of the lighter soils lime and manure have been found necessary for the best growth of vetch, but when these are used the vetch has usually done well.

Cow Peas: Five counties report demonstrations in the use of cow peas for the light sandy lands.

Soy Beans: There has been a very encouraging increase of interest in the growing of soy beans. Fourteen County Agents report a large amount of work on this legume; in some of the counties where soy bean demonstrations have been in progress for three or four years they are now grown extensively while in other counties the demonstrations have been started more recently but the almost uniform success of these demonstrations soon leads to a strong interest in this legume for the various purposes for which it is used, such as soil-building, seed, hay, pasture and silage.

Land Clearing: In the Northern Peninsula land clearing problems are prominent and several of the agents have been giving attention to these. In Iron county in April two demonstrations were held. The Board of Supervisors attended one of these and as a result purchased three machines to loan to the farmers. In June the agent gave parts of 16 days to demonstrations, about 25 acres being cleared under his direction. More recently five stump blasting demonstrations were conducted in Alpena county, eleven in Delta, twenty in Dickinson, and eighteen in Marquette.

Tree Planting: In five counties, in cooperation with the Department of Forestry, through Mr. Mandenberg, work has been done toward the reclamation of sandy areas by planting quick-growing trees. In Kalamazoo county blow sand ridges and other drift sand areas were so planted. In Manistee county poplar plantings were made on sand dunes near Manistee; pines will be planted between the poplars, later on. Several basket willow demonstrations were started. Three plantings of forest and ornamental trees were made. In Muskegon county demonstrations of planting begun earlier in six townships, are all showing a good growth. About 3,000 trees were ordered for this season. In Newaygo county a planting demonstration was started on an area of very light blow sand, with the object of eventually reforesting the whole section. In Ottawa county 25,000 cuttings of willows and poplars were planted in April; this was done by the men of two townships working in groups, at stated times. Later, fifteen acres of spruce and soft maple were planted on three different tracts for Christmas trees and quick basket lumber and as a demonstration in the utilization of waste lands.

Drainage: The interest in drainage has continued to increase. Methods and costs have been discussed at the institutes, extension

schools and other farmers' meetings. Demonstrations have been conducted in fourteen counties. In Muskegon, Ottawa, Saginaw and St. Clair counties, where there are large areas needing drainage, the demonstrations have led many farmers to use tile drainage; in Saginaw county 150 car loads of tile were used in one community; in St. Clair county on one farm alone, three car loads were used; in Ottawa county 40 farmers were induced through the demonstrations to drain their farms; in Muskegon county 15 demonstrations have been made and ditching machines have been purchased cooperatively by the farmers in four communities. In Alpena county four demonstrations of the use of dynamite for ditching in swampy land where men and teams can not work to advantage, were given. The difficulty in getting tile, the scarcity of labor and the lack of ditching machinery have checked the progress of this work in all of the counties this season.

FARM CROPS.

Standardization of Crops through Community and County Organization: A fundamental need in relation to larger and more economical production as well as successful marketing has been concerted action on the part of communities and counties in the elimination of varietal mixtures, and impurities, the replacing of the large number of poor varieties and the maintenance of the purity of these by community action. It is very gratifying to note the progress that has been made this year in the movement toward standardization of crops through community and county efforts. There have been formed 21 pedigreed seed associations and 6 potato growers' associations. In cooperation with the Farm Crops department a well organized movement has been started for locating all the pedigreed grain grown in the counties; for inspecting and certifying such fields of grain and advertising it so that it may be used for seed by larger numbers of farmers.

Red Rock Wheat: Special effort has been made to place the growing of Red Rock wheat and Rosen rye on a community and county basis and the results have been very encouraging. In 1913 a peck of Red Rock Wheat was sent to each of the Agricultural Agents then employed. The small demonstration plots made possible in this way interested many farmers and more demonstrations were made in 1914-15 with the result that in 1916 several counties began to make this variety their standard. The agents in these counties urged farmers having fields of this wheat to have it inspected and this has aided greatly in supplying the big demand that has arisen for pure Red Rock wheat.

Rosen Rye: The growing of Rosen rye has furnished an excellent example of the value and need of community action. Its superiority over common rye is at once admitted by all who have had an opportunity to see the two growing under similar conditions. This, coupled with the fact that it mixes by cross-fertilization, at once challenges the best that there is in community spirit in rye growing sections to show the possibilities of standardization for more profitable production and better marketing. The results of the lack of community action are very evident in the fact that of the estimated 15,000 acres of Rosen rye in the state, probably not more than 5% of it is 99% pure. St. Joseph county has made a good record in the introduction of Rosen rye having about 3,500 acres, the largest acreage of any of the counties of the state. However, the strong campaign that has been made for it this year promises

to make it the leading variety in a number of counties and in a few counties where rye is grown extensively, it is planned to make it the only variety grown.

Corn: In cooperation with the Farm Crops department sixteen counties started variety test plots this spring with a view to determining the best strain of corn for the different localities from the point of view of seed production per acre and also the best strain for silage purposes from the point of view of total nutrients per acre. Saginaw county has forty-five demonstrations with corn. Field selection of seed corn has been continued and seed testing work has been carried on through various channels, including the schools. The Farm Bureau of St. Clair county purchased a car load of excellent seed corn from Ontario and the farmers were well pleased with it.

Oats: Twenty counties report demonstrations of treatment for smut, use of fertilizers or value of the better varieties of oats. Considerable time was given to helping the Farm Bureau secure and distribute larger quantities of pedigreed oats such as the Worthy and Alexander. In the counties of the Upper Peninsula efforts are being made to determine the best strains of oats for that section; in Dickinson county last season tests were made with Worthy oats on twenty farms; in Schoolcraft county a policy of the Farm Bureau this season has been the encouragement of the production of pure, northern grown seed oats. In some sections a strain of Swedish Select oats is maturing earlier than other varieties this season.

Beans: Eighteen counties report special work on the bean crop in cooperation with the Departments of Botany and Farm Crops. Efforts have been made to get disease-free seed. For this purpose field selection of seed has been emphasized by demonstrations, conferences, circular letters and press articles. Comparative tests of Early Wonder, Idaho-grown and California-grown Michigan seed, Michigan hand-picked and Robust beans have been made in a number of counties; those with Robust beans in sixteen counties. Fertilizer demonstrations have been conducted and assistance given in control of insects. A large number of field inspections have been made to determine the nature and extent of diseases. This spring the agents gave considerable time toward increasing the acreage of beans by locating sources of good seed and helping the Farm Bureaus to distribute it and by spreading information on the best cultural methods by means of bulletins, press articles and meetings particularly in sections where bean growing had not been practised to any extent.

Potato Growing and Standardizing Demonstrations: The potato project conducted in cooperation with the Department of Botany and Horticulture through Mr. C. W. Waid has become well established in the state and very encouraging progress has been made with it this year, all of the counties reporting work on practically every phase of this important project. Growers are working more in groups and associations, and by this method varieties are being reduced to one or two of a standard commercial type; better cultural methods are being adopted, diseases controlled, and the way prepared for successful marketing through communities having car lots of standard varieties more uniform in size and freer from diseases. This community action is also doing much toward advertising the product through exhibits and other channels. For the standard varieties in large quantities the growers are receiving from five to ten cents more per bushel. This in turn gives a greater incentive to continued seed selec-

tion which is being promoted by all the agents both by the hill selection method and by the tuber unit method; this group activity is also leading to a wider adoption of the treatment of seed, a closer study of methods of planting to increase uniformity and yield, and a more general practice of spraying to control insect and fungous troubles. Fertilizer, seed-selection, seed-treatment, green-sprouting, and spraying demonstrations have been conducted by the agents and these are well distributed throughout the potato growing localities. Many field meetings have been held to give a general knowledge of the results of demonstration work.

Barley: Ten counties report work on barley. This consisted of tests of varieties, including Michigan Winter, Oderbrucker and Wisconsin pedigreed barley. Help was given the Farm Bureaus in securing and distributing seed and an effort was made to increase the acreage; an increase of 33% was reported in Dickinson county and 45% in Ontonagon.

Celery: Six counties report work with the growing and marketing of celery. Demonstrations for the control of blight were conducted in five counties and the results made known to as many growers as possible; in Muskegon county 40 men bought sprayers and arranged to buy blue-vitriol cooperatively.

FRUIT.

In twenty-two counties work with fruit has been conducted by the agents in cooperation with the Department of Horticulture, through Mr. J. H. Carmody. With the exception of that done in relation to marketing, the work has consisted largely of demonstrations, including those of pruning, spraying and grafting, of thinning fruit, making spray mixtures, controlling cut worms, and repairing injury done by mice girdling trees. Inspection of orchards has been carried on in seventeen counties. Control of insect and fungous troubles have required more attention than any other problems in fruit growing; warnings of conditions favorable to the development of such injury or of the presence of such troubles, were given by the agents through the press and at meetings. Farmers were assisted in orchard planting, in securing spray materials, in preparing the mixtures, in selecting and starting sprayers, and advised regarding time of spraying.

(See Exhibits and Marketing, also.)

CONTROL OF INSECTS.

In addition to the work for control of insects injurious to fruit, 13 counties in cooperation with the Department of Entomology have investigated and identified insects attacking crops and gardens, and advised measures for their control; these have included the Colorado beetle, the aphis on potatoes, wire worms, cut worms, melon insects, cabbage worms, weevils in stored wheat, and, in a number of instances, attacks of insects less well known.

CONTROL OF PLANT DISEASES.

In cooperation with the Department of Botany, this project with its three divisions of control of bean blight, of celery diseases and of grain smuts, has been forwarded as follows: 18 counties report treatment of wheat and oats for smut. Efforts will be made to make the practice general this fall and next spring in the counties growing these grains. County Agent Smith of Kent became interested in the new concentrated

formaldehyde method originated by Mr. H. J. Haskell of Cornell University, and included it in a circular on wheat smut to the farmers of his county. It has been used successfully in Kent and other counties and on account of its simplicity is liked by the farmers. The method has been tested for both wheat and oats in the Botany Laboratory and has been recommended by the department for treatment of these grains. Nine counties report work in control of bean diseases. In five of the six counties growing celery, demonstrations for the control of blight have been conducted. The results circulated, and the practices recommended have been adopted quite extensively. Assistance has been given in controlling diseases of onions, tomatoes and cabbage.

(See Farm Crops, also.)

LIVE STOCK.

Much has been done toward the improvement of live stock in cooperation with the live stock Extension Specialists, Mr. W. F. Raven and Mr. J. A. Waldron. Twenty-three community breeders' associations were formed in thirteen counties; seven cow testing associations have been organized and one reorganized. Feeding demonstrations were conducted in six counties. Balanced rations have been computed for many farmers. In work with cattle, 216 pure bred sires were purchased and about twelve were exchanged. Some of the purchases were made by individuals who had been interested by the agent, the latter usually making the selection of the animal; some purchases were made cooperatively through a breeders' association; others were made through credit associations in cooperation with the local banks.

In cooperation with the County School Commissioner and a local bank the agent in Cheboygan county outlined a project for live stock work among boys and girls. Through this cooperation the bank shipped in one carload of pure bred and grade Holstein heifers and distributed them among the boys and girls of the northern end of the county.

In Dickinson county, through the associations and by means of the agent interesting individual farmers through visits relating to live stock work, 15 pure bred sires were placed in the county; in Gogebic county ten were brought in in the same manner.

In Houghton county a survey of one section of the county taken in March, 1917, showed that the number of dairy cows had been doubled in three years. Estimates based on this survey and on those of two other localities would indicate that there had been an increase of more than 80% in the number of dairy cattle in the county in the last three years.

A live stock directory for Iron county issued in October, 1916, contains these significant results for three years' work: nine breeders' associations organized; 40 pure bred sires and 42 pure bred cows added to the live stock of the county; Guernseys, Holsteins, Jerseys and Ayrshires are the breeds adopted. Four pure bred sires and three pure bred cows were added this year, and three sires were exchanged. About 70% of the farmers are now interested in pure bred sires; three years ago, only 2% were interested.

In Marquette county a live stock census was taken. In continuation of the plans for live stock improvement inaugurated last year, seven pure bred sires and two pure bred cows were placed by the agent.

In Mason county the Ludington State Bank takes a note from the individual or group, at 4%, with practically no time limit; since January

1 by means of this credit, there have been brought into the county 22 registered Shorthorn sires, 22 registered Shorthorn heifers, and 9 registered Holstein heifers; previous to this time, the total number of Shorthorn sires in the county was 10, and Shorthorn cows 6.

In Menominee county in April, 1916, about 60 men formed an association which enables farmers to buy good stock advantageously for cash, or on time payments. Those wishing to purchase high grade or pure bred Holstein or Jersey cattle may borrow money from the banks; the payment of this is guaranteed by the association; the purchaser gives a note secured by chattel mortgage; the notes bear 6% interest, and are payable in eight equal quarterly installments. As a result 11 pure bred sires, 13 pure bred cows, about 60 grade cows, and 35 calves for calf club members have been brought into the county.

In Newaygo county a plan for calf clubs was worked out in cooperation with a committee representing the banks of Grant, Fremont and White Cloud in February, 1917, both dairy and beef calf clubs are included. Shorthorns for the beef and Guernseys for the dairy breed; the clubs are to be promoted through the Farm Bureau and the Boys' and Girls' Club work of the College. Every boy or girl who wishes to undertake the project, may enroll in one of the clubs. Each club member may purchase two calves, must decide upon the breed desired and indicate through what bank the contract is to be handled; a contract and a note for the value of a pure bred calf is then signed; the banks provide the cash for the purchase of the calves and the committee specifies the time at which the notes are to be paid. After all applications are in, the calves are to be purchased and distributed by lot among the club members. A carload of registered Shorthorn cattle, 14 sires and 18 heifers, was purchased by the Farm Bureau in Ontario, Canada, in April, and half the car load was distributed to club members in accordance with the above plan.

In Ontonagon county early in 1917 there were 31 registered Holstein sires, two registered Jerseys and three registered Guernseys, or in all 36 pure bred dairy sires, well distributed over the county; also one herd of registered Shorthorns, one of Polled Durhams, three Shorthorns and one Hereford sires. Of these about 12 have been placed since July 1, 1916. One of the pieces of live stock work done by the agent has been the management of the dairy herd on the County Farm. Accurate records are being made, and all feed costs, and the returns for expenditures made for feed, figured.

An exceptional piece of work is that being done in Wexford county where at a Farm Bureau meeting, December 11, 1916, Mr. Wm. L. Saunders offered to pay the difference involved in replacing every scrub or grade sire in the county with a registered one, the choice to be confined to Shorthorns or Holsteins and the purchases to be made through the Farm Bureau; the County Agent has given much attention to the project and thus far the purchase of 46 pure bred Shorthorn sires has been made possible by this generous offer; in addition 13 Shorthorn heifers have been purchased by the farmers.

In cooperation with the State Live Stock Sanitary Commission and the Bureau of Animal Industry of the U. S. Department of Agriculture, work for the control of transmissible animal diseases has been continued. Fifteen counties report visits from single calls in Marquette, Menominee, Muskegon and Ontonagon counties, through several in Ottawa, Allegan

Kent, Saginaw, St. Clair and Schoolcraft, to almost daily investigation at times in the counties where cholera had been prevalent earlier,—Branch, Kalamazoo, Lenawee, St. Joseph, and also Van Buren; in Lenawee county, the agent gave parts of 112 days, to the work. A total of 77 cases in thirteen counties has been reported this year, with no extended outbreak in any locality. The value of community action has been demonstrated by the results of this year's work. In all of the counties where the work has been carried on for the past two or three years it is stated that reports of outbreaks are now made promptly to the County Agent and that almost without exception he and the veterinarians find the parties involved willing to cooperate in treatment of herds, disinfection of premises and in establishing and maintaining quarantines. Two cases of tuberculoisis among hogs were found. Among cattle eleven herds and 245 individuals were tested for tuberculosis; two herds and 35 individuals were found affected and were killed. Two outbreaks of hemorrhagic septicaemia have occurred but no spread of the disease followed. Five counties conducted work for the control of contagious abortion.

POULTRY.

Twelve counties report work with poultry. In cooperation with the Poultry department plants were inspected; assistance was given in the selection and purchase of poultry; in making plans for poultry houses and ventilating systems; in setting up incubators and starting farmers in the use of them; in the formation of poultry clubs; in feeding problems; in control of diseases and in marketing of eggs. In Iron county a local bank agreed to assist in financing pure bred poultry work for clubs. In Menominee and Marquette counties egg producers' associations were formed; in the latter four poultry meetings were held. The high price of eggs has caused an interest in the poultry industry. In Manistee county a poultry show was held; this revived interest in the county association and monthly meetings were planned.

FARM MECHANICS.

Many requests for assistance in farm engineering problems have come to the agents. In fifteen counties in cooperation with the Department of Farm Mechanics, much assistance has been given in selecting suitable sites for farm buildings; in planning twenty-two general purpose barns; ten dairy barns; one beef feeding barn; two milk houses; six silos; in planning and installing two hydraulic rams; in estimating cost of materials for various improvements; and in selecting barn equipment. The agents have emphasized the importance of good housing conditions for stock; as a result they have been called upon to assist in remodeling several barns and in planning thirty ventilating systems. In a few cases they have taken prospective builders to see modern barns. Dickinson, Gogebic, Houghton, Ontonagon and Schoolcraft counties have given much attention to plans for barn buildings. In Schoolcraft county where a number of farmers are contemplating the building of barns, the agent built a small model of the braced rafter construction; this proved to be of real interest and led to several requests for plans and lists of materials. In Kent county the agent assisted in working out floor plans for a barn which is to serve as a demonstration.

Demonstrations of improvements in farm homes have been conducted

in six counties; two lighting, several water supply, and twenty-five septic tank systems have been installed.

FARM MANAGEMENT DEMONSTRATIONS.

As indicated in last year's report the tendency in Farm Management Demonstration work has been to put more emphasis upon the value of keeping accounts. At the annual conference the Farm Management project was modified to make this possible. The report of Mr. Karl H. McDonel, Assistant Demonstrator, shows that in cooperation with the County Agents in sixteen counties 727 account books have been placed this year; at the close of 1916 ninety-three books were returned to the demonstrators who summarized them and reported to the owners their labor income for the year, with tables making it possible for each farmer to compare his results with those of other farmers of the same area. The County Agent is then in better position to suggest changes in the farm management of each area and to give assistance where it is requested. In addition to the work relating to accounting 332 farm records were taken; the first year's demonstration was completed in Mason, St. Clair and St. Joseph counties, the second year's demonstration in Branch, Newaygo and Saginaw counties. The work was explained at 129 meetings with an attendance of 2,744. Mr. C. P. Reed, Farm Management Demonstrator, resigned May 15; Mr. McDonel continued the work until June 30; and Mr. Charles H. Graves has been appointed Farm Management Demonstrator to begin work September 1. The work will be continued in cooperation with the County Agents as outlined at the annual conference.

BOYS' AND GIRLS' CLUBS.

In cooperation with the agents in twenty-five counties the Club Leaders have organized 224 Boys' and Girls' Clubs with an enrollment of about 5,000; Kent county with 1,650 members and Saginaw with 1,380 have the largest enrollments. The clubs include bean, corn, potato, garden, poultry, pig, farm accounting and stock judging clubs for the boys, and baking, canning and garment making clubs for the girls. One hundred twenty-eight meetings with an attendance of 3,814, have been held; 12 demonstrations of club work have been given; 36 exhibits of club products, eight club fairs and two club round-ups have been held. In September, 1916, Kent county reported that 266 boys had completed the garden project and produced a net profit of $844. Twenty-two garden clubs exhibited their products, each in its own community, but all on the same day. The results for this year will greatly exceed those of last. As a fitting close for the year's club work, a Club Day was held at Grand Rapids, December 16, when the total attendance of members, parents, and club leaders was 310, and where the spirit was the best that had yet been manifested toward the work. In Allegan county, a Round-Up at which a play demonstration and a canning demonstration were given, was held in November; 250 rural pupils and teachers attended. In Marquette county, thirty potato club members completed their project, made exhibits of their potatoes; many of these exhibits were sent to the State Potato Show at Escanaba. In Saginaw county the four exhibits of club products included dozens of garments; canned goods, beans, poultry and pigs.

GARDENING.

On account of the national food situation, there has been an unusual interest in gardening this season. Seventeen counties report work on this project. In some localities, all vacant land and vacant city lots have been turned into garden plots; 5,871 acres have been reported as so used; this is especially noticeable in Alpena, Dickinson, Marquette, Ottawa, and Presque Isle counties; In Houghton county the gardens have increased in size as well as in numbers; in Alpena the Boy Scouts have been caring for an acre; in Manistee, over 220 acres out of town have been devoted to gardens; in St. Clair 350 acres are in gardens tended by boys and girls; in Kent where 5,400 acres have been used for gardens there is an increase over last year of 250% in number and of 280% in acreage. The garden project has been financed in various ways. Land, seed, and care have been donated in some counties; in some loans were obtained, while in others appropriations have been made for the purchase of seeds or other supplies. Twelve thousand six hundred dollars has been given for use in garden work, in Houghton county, over $600 has been pledged by school boards and civic clubs; in Manistee $4,000 has been raised by the Manistee Board of Commerce; in St. Clair $8,000 has been raised, $1,000 of which was given by a factory owner for rent of land for boys' and girls' gardens.

HOME ECONOMICS.

In cooperation with the Division of Home Economics, 25 counties have forwarded this project by means of demonstrations and lectures; 129 demonstrations with an attendance of 3,931 and 120 lectures with an attendance of 3,897, were given; in addition 16 talks and 17 demonstrations relating to child welfare work were held. In furtherance of the food conservation policy 107 canning demonstrations were given in nineteen counties. Plans have been made to reach practically all sections in many of the counties, with these demonstrations during July and August, and local demonstrators are now being trained.

Miss Ilena M. Bailey, Home Demonstration Agent of the United States Department of Agriculture, who has been located in St. Joseph county for the last fifteen months concluded her work on June 30th. During the time she was in Michigan she started and developed the girls' club work, assisted in the organization of several home economics clubs, and helped a number of other women's clubs to work out programs on home economics subjects. She conducted one-week schools in home economics, general women's institute meetings, numerous canning demonstrations and made a survey of more than a hundred farm homes to determine the needs of farm women which can be met by extension workers of the College and department. Miss Bailey has also been interested in many lines of miscellaneous work which will be of value to the women of St. Joseph county.

EXHIBITS AND FAIRS.

The results of the demonstration work in the counties have been given wider circulation through exhibits at the county fairs, at the Michigan State Fair at Detroit, at the West Michigan State Fair at Grand Rapids, at the Northern Michigan Agricultural Congresses at Cadillac and Ludington, at the State Potato Show at Escanaba, and at various local meetings. The policy followed in all of these exhibits has been to make them

educative in character. In 24 counties one or more exhibits of the results of demonstrations, or of the county's products, have been made, a total of 84 in all. Farm Bureaus have taken advantage of the opportunity to reach large numbers of people through local fairs. Exhibits have been arranged and the County Agents and assistants have been present to explain the work, to answer questions and to distribute bulletins and circulars. Some of the results that have thus been brought to the attention of a larger number of people have been those of soil testing, seed testing and treatment, the work of the crop improvement association, tuberculin testing, testing of milk for butter fat; while some of the crop exhibits made have included grains from demonstration plots; grasses and clovers; and vegetables. Exhibits of live stock and stock judging by teams from boys' and girls' clubs were featured at a number of local fairs. Six counties held exhibits of club work. (See Boys' and Girls' Clubs also.) County and local potato exhibits were held in five counties; Dickinson, Kent, Newaygo, Schoolcraft and Wexford; Ontonagon sent an exhibit to the Chicago Land Show. Exhibits of fruit were made by Berrien county at the State Fair at Detroit and at the Benton Harbor Fruit Festival; by Kent county at the State Horticultural meeting at Grand Rapids; by Mason county at the West Michigan State Fair and the West Michigan Apple Show at Ludington; by Menominee county at both the Stephenson Fair and the Horticultural Show at East Lansing; by Muskegon county at the Fruitland Township Community Fair and the West Michigan Apple Show; by Newaygo county at the Fremont and Grant Community Fairs, and at Ludington; and by Ontonagon county at East Lansing.

MARKETING.

Twenty-one counties, cooperating with the Office of Markets, report work on marketing, including either buying or selling or both. In this the agents have assisted by issuing exchange lists for their own counties and by putting farmers in touch with Farm Bureaus in Michigan and other states and with federal sources of information as to supply, demand and prices; by securing the interest of groups in forming associations and arranging meetings through which the methods and details of such organizations were discussed by specialists in marketing from the College or the department.

The following associations for cooperative marketing have been formed: Two associations for the marketing of hay in St. Clair county, now under one management; eight milk producers' associations, two in Berrien county, one in Branch, one in Kent, one in Muskegon, one in Saginaw, and two in St. Clair; four fruit growers' associations, one in Allegan county and three in Berrien; celery growers' associations in Muskegon and Ottawa counties, now cooperating in the marketing of their product; one sugar beet growers' association in Saginaw county and two in St. Clair; a cabbage growers' association in Branch county and a truck growers' association in Ottawa; egg selling associations in Marquette and Menominee counties; five live stock shipping associations; six fruit associations were reorganized, three in Van Buren and three in Berrien. A cooperative association was organized in Alpena county to enable farmers to sell their products in carlots and to buy supplies such as spraying materials, binder twine and coal. In Ottawa county a cooperative elevator company was organized. Community breeders' associa-

tions and live stock credit associations have purchased pedigreed sires and also pedigreed and high grade cows; in addition to this, special plans for purchasing live stock directly through the Farm Bureaus have given excellent results. (See Live Stock, also.)

The buying and selling activities have included a wide range of items, such as fertilizers and lime; seeds of all kinds; pure bred and high grade live stock; hay and other feeds; wool; milk, butter, cheese and eggs; peaches, apples, berries, and grapes; potatoes, beans, cabbage, and celery; and spraying materials. In Saginaw county two carloads of dairy feed were purchased and in St. Clair county three carloads, with a saving of about $6 per ton in each county.

A large amount of buying and selling of potatoes has been done through the Farm Bureaus. The basis for this work has been the standardizing of varieties and the control of diseases. The unusual demand for seed together with scarcity and high prices greatly increased the activities of the Farm Bureaus this season in the distribution of potatoes for seed.

WINTER MEETINGS FOR DISCUSSING RESULTS AND MAKING PLANS.

The following table gives a statistical statement of the winter meetings:

WINTER MEETINGS FOR DISCUSSING RESULTS AND MAKING PLANS.

County.	Sessions of Farmers' Institutes.	Attendance at Farmers' Institutes.	Sessions of Extension Schools.	Attendance at Extension Schools.	Home Economics at Extension Schools.				
					Demonstrations given.	Attendance at demonstrations.	Lectures given.	Attendance at lectures.	Health talks and demonstrations.
Allegan	26	2,178	4	168	......	......	......	......	......
Alpena	6	234	......	......	......	......	......	......	......
Berrien	65	4,775	48	2,248	3	168	5	290	1
Branch	9	1,820	19	829	3	132	5	220	1
Cheboygan	2	120	8	240	3	84	5	140	1
Chippewa	......	......	......	......	......	......	......	......	......
Delta	......	......	......	......	......	......	......	......	......
Dickinson	......	......	6	......	1	11	1	14	......
Gogebic	6	480	......	......	......	......	......	......	......
Houghton	3	133	......	......	4	224	3	165	......
Iron	......	......	......	......	......	......	......	......	......
Kalamazoo	33	2,306	......	......	4	116	2	58	1
Kent	8	357	36	1,010	3	52	5	70	1
Lenawee	44	6,530	26	918	3	102	8	284	1
Manistee	17	3,715	19	584	......	......	......	......	......
Marquette	18	934	12	309	14	458	14	464	......
Mason	22	1,146	21	499	3	93	5	155	1
Menominee	17	1,279	12	376	3	77	3	77	......
Missaukee	......	......	......	......	......	......	......	......	......
Muskegon	2	105	11	79	3	48	5	80	1
Newaygo	14	611	12	450	3	60	5	100	1
Ontonagon	24	1,018	......	......	......	......	......	......	......
Ottawa	14	1,777	32	1,132	......	......	......	......	......
Presque Isle	3	145	......	......	......	......	......	......	......
Saginaw	19	1,663	25	268	3	48	5	80	1
St. Clair	14	2,970	11	356	7	179	9	213	2
St. Joseph	49	3,409	12	599	15	364	17	447	2
Schoolcraft	9	286	......	......	3	104	3	106	......
Van Buren	32	2,158	22	1,222	3	156	5	260	1
Wayne	......	......	......	......	4	104	2	52	1
Wexford	5	625	......	......	......	......	......	......	......
Totals	461	40,774	336	11,287	85	2,580	102	3,275	16

The policy adopted by the County Agent Conference in June, 1916, viz., that the work of the institutes in counties having agents should be so outlined that it would contribute directly to the agricultural program of the county and to certain definite projects continuing through the year or until satisfactory results are obtained, was very generally followed. The projects outlined at the Conference in November were adapted by the agents to the varied needs of their counties and communities and the work was organized through committees so as to make the execution of the plans effective and thorough. These projects were then discussed, outlined, and adopted at the institutes, extension schools and the special community meetings. At such meetings and conferences the demon-

strators were secured, and the orders were placed for the materials needed in making many of the demonstrations, such as seeds, lime, tile, and fertilizer. The meetings also furnished the opportunity for the formation of cow testing associations, community breeders' associations, boys' and girls' clubs, the placing of farm accounts books, and for planning home improvements.

FOOD EMERGENCY WORK.

To meet the food emergency situation which developed as a consequence of the entrance of our country into war, surveys were made to determine the needs of the counties; the outstanding problems which presented themselves at once were those of finance, seed and labor. In financing the increased operations in agriculture, boards of supervisors and banks gave great assistance. In Alpena county the Board of Supervisors appropriated $10,000 for the purchase and distribution of seed and in Cheboygan $3,000; in Van Buren county the Board of Supervisors guaranteed the loans made by the banks to farmers for purchase of seeds. Banks in Delta, Mason, Houghton, Menominee, Newaygo, Saginaw, Wexford, and Chippewa counties extended credit to farmers for purchase of seed; the Cadillac State Bank in Wexford county advanced seed for bean plots on condition that the seed be paid for from the sale of the crop; in Chippewa county, banks advanced money for seed to farmers on notes without interest; and in Alpena county, a local bank, gave $10,000 for purchase of seed; in Cheboygan county, farmers worthy of credit will be given until December 1, 1917, to pay for seed and will be charged no interest, while in Marquette county bankers decided to extend credit to farmers until November 15, without interest.

Several large mining companies in Houghton county arranged to fence and plow old pastures at their own expense for use of their employees. Large factory owners in St. Clair county turned over $1,000 for boys' and girls' gardens. In Schoolcraft county the agent was placed in charge of a fund of $6,000 to be used in financing the farmers who needed this help in procuring seed. Quantities of seeds were distributed to farmers in Cheboygan, Chippewa, Delta, Dickinson, Houghton, Lenawee, Manistee, Mason, Menominee, Newaygo, Ontonagon, Ottawa, Schoolcraft, St. Clair, St. Joseph, Van Buren and Wexford counties through the Farm Bureaus in cooperation with other interested agencies in the county; this location and distribution of seed greatly facilitated the spring seeding. In Manistee county 120 acres from the golf course were given to the Boy Scouts for raising beans; the Manistee Board of Commerce raised $4,000 to carry on this work.

Nearly all of the counties report assistance given in securing labor. Some counties were able to supply the necessary labor locally. In counties having large cities and in those adjacent to large cities it has been possible to meet the labor needs satisfactorily. This is illustrated by the work done in Kent county; through the Farm Bureau cooperating with the Association of Commerce, the Board of Education and the Grand Rapids News in Grand Rapids, and with the Farm Bureaus of adjoining counties, men and boys were secured for farms in Kent, Allegan, Newaygo and Ottawa counties; in this way 102 men and 281 boys were secured to help on farms. In Lenawee, St. Clair and Wayne counties, considerable help was obtained from Detroit. In Lenawee county 30 men were secured for farmers. In St. Clair county 108 men were

placed on farms; reports to the County Agent indicate that over 50% of this help was very satisfactory.

CONFERENCES.

During the year five conferences were held for planning the work. Two of these were held at the College and three in the Upper Peninsula. Reference was made at the beginning of this report to the work of the Annual Conference at the College, November 20-24. One of the conferences of the Upper Peninsula was given to all the projects of that section, the other two considered special problems; one relating chiefly to live stock and the other to methods of forming and conducting national Farm Loan Associations.

FIELD WORK OF ASSISTANT STATE LEADERS AND STATE LEADER.

Th field work of the State Leader and the Assistant State Leaders has been largely as follows:

a. Explanation of County Agricultural Agent work in counties not having agents and assisting in organizing such counties for Farm Bureau work and in selecting agents.

b. Helping in the further development of Farm Bureau organizations in counties having agents.

c. Conferences with County Agents and Farm Bureau officers in regard to state, county and community projects and methods of putting these into effect.

d. Attending meetings in the counties to assist in forwarding some particular project.

e. Studying the methods and results of the work in the different counties for the purpose of giving to new counties the benefits of experience in the different phases of County Agent work.

Mr. J. W. Weston was appointed Assistant State Leader for the Upper Peninsula, November 1, 1916. Mr. Weston has made 31 visits to counties having agents and 34 visits to counties without agents. He helped to conduct 73 meetings with a total attendance of 3365.

Mr. C. B. Cook, Assistant State Leader, has made 67 visits to counties having agents and 43 to counties without agents. In doing this work he has addressed 157 meetings with a total attendance of 14,470.

In field work the State Leader has made 66 visits to counties having agents and 40 visits to those without agents. In this work he has addressed 96 meetings with a total attendance of 12,814.

In closing this report the State Leader wishes to call special attention to the fact that the County Agricultural Agent movement is essentially a cooperative one. Its success depends entirely upon the degree of concerted action that can be attained on the part of the people of the county, and of the representatives of the Agricultural College and of the United States Department of Agriculture. The County Agricultural Agent's functions are many but he is primarily an organizer and a coordinator of the activities of those concerned with the agricultural development of his county. The results outlined in this report have been achieved because many men, women, boys and girls have worked toward the common end of making agriculture more profitable and country life more satisfying and attractive. It would be a pleasure to

give personal recognition in this report to all those who have helped to make this work successful but that is impossible. In all the counties there are public spirited men and women giving time, energy and thought to this movement without financial compensation and they are rendering a great service to agriculture. The different departments at the College have always given willingly all the assistance possible and the Department of Agriculture has brought to our state the value of its experience in the broader field and has helped to inject into our work more of the national point of view and a keener consciousness of the national aspects of agriculture.

East Lansing, June 30, 1917.

REPORT OF EXTENSION SCHOOLS.

BY R. J. BALDWIN.

Extension Schools were held during the winter months from November 1st to March 15th. The school programs began Tuesday and continued for four days rather than five as in former years. The majority of places visited were in counties having agricultural agents who assisted in the instruction given, and planned local arrangements.

Courses for the week were made up of eight lectures and demonstrations by each of two instructors. The courses offered were as follows:

Farm Crops.
Soils.
Horticulture.
Farm Management.
Farm Bookkeeping.
Insect Pests.
Dairy Husbandry.
Animal Husbandry.
Farm Engineering.
Home Economics, 1st year.
Home Economics, 2nd year.

The special assistance of Wm. Murphy in soils, C. M. Kidman in farm management, and Ashley Berridge in dairy husbandry was secured for the winter season as extension school instructors.

The following tables summarize the agricultural and home economics extension schools of the year:

Place.	Average attendance.	Total No. enrolled.	Lectures given.	Year.	Agriculture Subject.
Addison	20	26	6	1st	Farm Crops, Farm Mgt., House. Eng.
Aetna	43	60	16	1st	Soils, Crops, Feeds and Feeding.
Algansee	52	380	19	3rd	Soils, Feeds and Feeding, Live Stock.
Algonac (Marine City)	35	45	11	1st	House. Eng., Dairy Feed., Farm Mgt.
Allegan	22	62	16	1st	Farm Mgt., Crops and Soils, Dairying.
Ashland	27	80	18	1st	Dairying, Soils-Crops, Farm Mgt. Community Work.
Batavia	15	47	11	1st	Soils, Farm Mgt., Dairying.
Benton Harbor	75	100	14	1st	Fruit, Potatoes.
Berlin (Talmadge)	25	45	15	2nd	Potato Culture, Soils, Fruits.
Big Prairie	38	50	18	1st	Feeds and Feeding, Farm Crops, Soils.
Britton	20	40	16	1st	Farm Mgt., Feeds and Feeding, House. Eng.
Brookside	40	55	16	1st	Farm Crops, House. Eng., Farm Mgt.
Buchanan (Mt. Taber)	40	50	8	1st	Feeds and Feeding, Soils and Crops.
Burchville	12	35	17	1st	Dairy Feeding, Farm Mgt., Crops.
Cadmus	24	31	16	2nd	Soils, Crops, Farm Mgt.
Caledonia	43	52	12	4th	Live Stock, Soils, Crops.
Carlisle	23	32	8	1st	Soils and Fertilizers, Dairying.
China Twp	45	60	14	2nd	Dairy Feeding, Crops, Farm Mgt.
Colon	44	222	18	1st	Soils and Fertilizers, Dairy, Farm Crops.
Coloma	45	50	16	1st	Potato Culture, Hort., Soils.
Coopersville	30	47	16	2nd	Soils, Crops, Feeds and Feeding.
Dublin	31	25	13	1st	Soils, Crops and Farm Mgt.
Durand	31	46	12	3rd	Feeds and Feeding, Crops, Farm Mgt.
Eau Claire	60	85	9	1st	Feeds and Feeding, Soils, Crops (potatoes).
Freeport	90	21	16	1st	Farm Mgt., House. Eng., Crops.
Fennville (Ganges)	42	104	16	1st	Farm Mgt., Dairying, Soils.
Greenville	44	65	16	1st	Crops, Soils, House. Eng., Potato Diseases.
Gilead	30	47	14	1st	Soils, Feeds and Feeding, Farm Mgt.
Harbor Springs	15	51	16	1st	Animal Husbandry, Crops and Soils.
Hartford	62	200	18	1st	Soils, Crops, Dairying, Fruit Growing.
Hudson	30	80	13	1st	Soils, Farm Mgt., Dairying, Crops, Abortion in Cattle.
Holland	55	75	14	1st	Soils, Dairying, Farm Mgt.
Ironton	62	90	16	1st	Dairying, Farm Crops.
Kent City	42	75	15	2nd	Alfalfa, Potatoes, Hort., Soils, Dairying.
Lowell	35	62	14	1st	Soils and Crops, Animal Husbandry.
Maple Rapids	28	65	13	1st	House. Eng., Dairying, Soils, Crops.
Montague	19	46	17	1st	Soils, Crops, Potatoes, Dairying.
Monroe	22	50	11	2nd	Horticulture, Crops.
New Richmond	23	35	13	3rd	Dairying, Fruit, House. Eng., Farm Mgt.
Onekama	26	75	14	1st	Fruit, Miscellaneous Agr'l Crops.
Paw Paw	56	115	16	1st	Fruit, Soils, Poultry.
Petoskey	43	89	16	2nd	Horticulture, Dairying.
Ravenna	25	40	10	1st	Drainage, Dairying, Potato Diseases.
Reese	32	63	16	1st	Feeds and Feeding, Crops, House. Eng.
Riley	30	42	12	3rd	Feeds and Feeding, Farm Mgt.
Rockford	35	100	16	1st	House Eng., Potato Diseases.
Saginaw	14	30	16	3rd	Soils, Crops, Live Stock.
Scotts	23	28	16	2nd	Farm Mgt., Insect Control, Soils, Crops.
Scottville	15	47	12	1st	Hort., Dairying, Community Organization.
Springport	20	30	12	1st	House. Eng., Soils, Animal Husbandry.
South Haven	28	51	12	1st	Poultry, Soils, Insect Control.
Three Oaks	29	43	16	2nd	Horticulture, Dairying.
Three Rivers	33	75	12	3rd	Small Fruits, Poultry, Farm Mgt.
Taymouth	8	12	5	1st	Soils and Crops, Farm Mgt., Soils.
Vestaburg	14	30	12	1st	Feeds and Feeding, Crops, Soils.
Victory Twp	30	43	15	1st	Soils, Farm Mgt., Crops, Dairying.
Vergennes	14	27	16	1st	Soils, Dairying.
Total	2,849	3,731	801		

Place.	Average attendance.	Total No. enrolled.	Lectures and demonstrations.	Year.	Home Economics—Subject.
Algonac (Marine City)	17	30	10	1st...	First year school.
Bath	18	25	10	1st...	First year school.
Berlin (Talmadge)	18	30	10	2nd..	Second year school.
Big Prairie	20	34	10	1st...	First year school.
Britton	38	40	3	1st...	First year school.
Cadmus	34	50	10	1st...	First year school.
Charlotte	157	310	10	2nd..	Second year school.
China Twp	32	42	10	2nd..	Second year school.
Chocolay	16	23	6	2nd..	Second year school.
Coloma	56	136	10	1st...	First year school.
Constantine	29	66	8	2nd..	Second year school.
Flushing	35	67	8	2nd..	Second year school.
Dice	16	37	10	1st...	First year school.
Gwinn	16	20	6	1st...	First year school.
Harbor Beach	35	82	9	1st...	First year school.
Hancock	56	72	7	2nd..	Second year school.
Hartford	14	23	10	1st...	First year school.
Lawrence	52	114	20	1st...	First year school.
Lowell	52	114	10	1st...	First year school.
Marlette	40	91	11	1st...	First year school.
Marquette	25	32	4	2nd..	Second year school.
Mendon	23	29	10	2nd..	Second year school.
Montague	16	32	10	1st...	First year school.
National Mine	75	82	6	2nd..	Second year school.
Portland	23	53	9	2nd..	Second year school.
Plymouth	26	53	8	2nd..	Second year school.
Skandia	25	35	6	2nd..	Second year school.
Sturgis	32	73	9	1st...	First year school.
Sands	29	34	6	2nd..	Second year School.
Springport	44	71	9	1st...	First year school.
Scotts	29	47	8	2nd..	Second year school.
Summit Twp	31	50	10	1st...	First year school.
Union City	44	83	10	1st...	First year school.
White Pigeon	35	75	9	1st...	First year school.
Wolverine	28	50	10	1st...	First year school.
Total	1,236	2,205	312		

East Lansing, June 30, 1917.

REPORT OF JUNIOR EXTENSION WORK.

BY E. C. LINDEMANN.

The accomplishments and progress in Junior Extension work for the year may be reviewed under the following headings:

Enrollments: The enrollments for club membership are taken during the winter and spring months. For the season of 1915-16 the total enrollment for the state was 5920. These children were members of 394 clubs located in 54 counties. The enrollment for the season of 1916-17 is 27,654. The increased enrollment is no doubt due in a large measure to renewed interest in gardening as a result of the war. There are now 61 counties organized with 682 clubs.

Leadership: As the enrollments increase there are greater demands for supervision. It has been my policy to keep the size of the enrollment in proportion to the available leadership. The state staff now consists of the following persons:

E. C. Lindemann, State Club Leader.
C. A. Spaulding, Assistant State Club Leader.
Anna B. Cowles, State Club Leader for Girls.
Barbara Van Heulen, *Assistant State Club Leader for Girls.
R. N. Kebler, Assistant State Club Leader for Upper Peninsula.
W. E. J. Edwards, *Specialist for Live Stock Clubs.
Margaret Justin, *Home Economics Specialist in Upper Peninsula.

In addition to the state staff there are 36 employed club leaders in various counties of the state. There are 23 permanent County Agricultural Agents who assist in supervising clubs, and 6 of the temporary State Agents also assist. In 29 counties the Commissioner of Schools gives active assistance in organizing and supervising clubs. In 10 counties the County Y. M. C. A. Secretary renders a similar service. In addition to those mentioned above who are giving some form of professional leadership to this work there are 682 volunteer local leaders.

Training for Leaders: State, district and county training schools are being conducted for the purpose of training leaders in the technique of club supervision. To date there have been conducted 4 state training schools, 2 district training schools and 6 county training schools. Each of the State Normal Colleges also conducts a short course for the purpose of training teachers for this work. Approximately 500 persons have been reached through these schools.

Projects: All of the projects of previous years are still being used and in addition the following new ones are being tried:

Handicraft.
Cow-testing.
Calf raising.
Mother-daughter canning.

STATISTICAL SUMMARY OF THE PRESENT STATUS OF CLUB WORK.

Club leaders on State Staff	7
Paid County club leaders	36
School Commissioners assisting	29
Permanent County Agricultural Agents assisting	23
Temporary State Agents assisting	6
County Y. M. C. A. Secretaries assisting	10
Volunteer local leaders	682
Number of clubs organized	682
Number of counties organized	61
Number of club members	27,654
Value of food products produced by club members, 1916	\$26.468.22

*Miss Van Heulen has a temporary appointment.
*Mr. Edwards gives part time to this work.
*Miss Justin supervises the girls' work for the Upper Peninsula.

*Cost of conducting club work, 1916	$6,700.00
*Funds raised by local communities for conducting clubs, 1917	$9,000.00
*Funds supplied by U. S. Department of Agriculture and Michigan Agricultural College, 1917........	$12,000.00
State, district and county training schools held....	12
Projects being conducted	13

East Lansing, Mich., June 30, 1917.

REPORT OF EXTENSION WORK IN FARM CROPS.

BY J. W. NICOLSON.

The greater part of the Extension work in Farm Crops has been devoted to the pedigreed grain project. Three months in the winter were given over largely to extension school work where this project was taken up, together with outlines of best cultural methods, crop rotations, etc. The remainder of the year was spent in giving lectures and conducting demonstrations, supplemented by some farm visitation work. Considerable office work has also been necessary to handle the correspondence connected with the inauguration of the pedigreed grain project as now outlined.

The Michigan Experiment Association was reorganized January 15, 1916, and the name "The Michigan Crop Improvement Association" was adopted. There are now thirty-seven local associations with a membership of five hundred seventy-one, and there are three hundred thirty-one state members, making a total of nine hundred two.

During the past year, cooperative tests were carried on with members of the association as follows:

744 tested a peck of Red Rock Wheat.
146 tested a peck of Rosen Rye.
180 tested a peck of Winter Barley.
135 tested a half bushel of Pedigreed Oats.
62 tested a half bushel of Spring Barley.
184 tested 2 qt. samples of Corn.
35 tested 2 qt. samples of Soy Beans.
4 tested 2 qt. samples of Cow Peas.
25 tested 1 pound of Grimm Alfalfa.

During the fall of 1916, there was not enough Red Rock wheat to supply the demand. Due to natural increase and the information given farmers on how to care for these grains, there will be enough seed of these valuable varieties to sow a great part of the acreage of the state this fall.

*Figures are approximate.

SUMMARY OF FARM VISITS AND MEETINGS OF EXTENSION SPECIALISTS.

Farms visited	181	
Demonstrations held	20	attendance 461
Lecture meetings	40	attendance 1,652
Extension schools conducted	20	

East Lansing, Mich., June 30, 1917.

REPORT OF EXTENSION WORK IN LIVE STOCK.

BY W. F. RAVEN.

The following associations were organized during the fiscal year 1916-1917:

BREEDERS' ASSOCIATIONS.

Berrien County Holstein Breeders' Association.
Lenawee County, Jersey Breeders' Association.
Berrien County Guernsey Breeders' Association.
St. Clair County Jersey Breeders' Association.
Mason County Shorthorn Breeders' Association.

COMMUNITY BREEDERS' ASSOCIATIONS.

Ashland Shorthorn Association, 29 members, 3 sires.
Schoolcraft Guernsey Association, 22 members, 3 sires.
Cheboygan Holstein Association, 28 members, 3 sires.
Skandia Holstein Association, 12 members, 3 sires.
Yalmer Holstein Association, 18 members, 3 sires.
Empire Shorthorn Association, 19 members, 3 sires.
Richmond Guernsey Association.

LIVE STOCK ASSOCIATIONS.

Cloverland, Sheep Growers' Association.
Doster, Duroc-Jersey Swine Association.
Cadillac, Cow Purchasing Association.

Through the activities of the County Agents of Wexford county, Messrs. Zimmer and Piper, and the generosity of Wm. L. Saunders of Cadillac, Wexford county is rid, or nearly so, of grade and scrub bulls in service in that county. We believe this is the only county of like population in the United States that can show as good a record.

Many of the Community Breeders' Associations organized have ceased their activities as associations and do not hold association meetings. The members of these associations are using pure bred sires of the breed adopted by the association of which they were a member, with one exception.—Barryton, Mecosta county.

SUMMARY.

	No.	Attendance.
Farm Visits	38	
Demonstration Meetings	43	863
Lecture Meetings	37	2,363
Extension Schools	11	

East Lansing, Mich., June 30, 1917.

REPORT OF EXTENSION WORK IN COW TESTING ASSOCIATIONS.

BY J. A. WALDRON.

The Cow Testing Association work has been carried on during the past year in cooperation with the Dairy division of the United States Department of Agriculture.

The method of procedure has been to aid in the organization, reorganization, and supervision of cow testing associations; to give instruction in the improvement, feeding and care of dairy cattle in extension schools during the winter, and in other public gatherings throughout the year.

July 1, 1916, there were ten cooperative cow testing associations in Michigan with a membership of 250 farmers owning 3,529 cows. The associations that have completed a year's work since July 1, 1916, have been reorganized, with the exception of one division of the Allegan association that has discontinued operations temporarily.

Five new associations have been organized and have begun work since July 1, 1916. One association, the Saginaw Valley, which had been organized prior to that date began work during the year.

The following fifteen cooperative Cow Testing Associations were in operation in Michigan July 1, 1917:

1—Newaygo County Cooperative Cow Testing Association.
2—Kent County Cooperative Cow Testing Association. No. 1.
3—Allegan County Cooperative Cow Testing Association. No. 1.
4—St. Clair Co. Cooperative Cow Testing Association. No. 1.
5—Lenawee County Cooperative Cow Testing Association. No. 1.
6—Berrien County Cooperative Cow Testing Association. No. 1.
7—Berrien County Cooperative Cow Testing Association. No. 2.
8—Kalamazoo Co. Cooperative Cow Testing Association. No. 1.
9—South Ottawa Co. Cooperative Cow Testing Association.
10—Lenawee County Cooperative Cow Testing Association. No. 2.
11—1st Cloverland Cooperative Cow Testing Asso. (Menominee Co.)
12—St. Joseph County Cooperative Cow Testing Association.
13—Van Buren Co. Cooperative Cow Testing Association. No. 1.
14—Saginaw Valley Cooperative Cow Testing Association. No. 1.
15—Branch County Cooperative Cow Testing Association. No. 1.

All of the associations had a full membership and were on a sound financial basis. There were in these fifteen associations, July 1, 1917, 408 farmers cooperating, with 5,642 cows on test.

Great assistance was given this work during the year by the loyal and hearty support of the County Agents in whose counties cow testing associations were located. In many cases they have made possible the organization of an association. They have, without exception, aided by giving the work publicity, directing the organization campaign, and supervising the work after the association began work. The work of these men has been an invaluable aid to this project.

It has seemed more important to reorganize and keep active the old associations than it has been to organize new associations. The reason for this is that greater benefits are derived from the work when it is continued from year to year than when it runs but one year and is discontinued. A large part of the time, consequently, has been spent in reorganization work and in supervising the associations already in operation. It is believed greater service can be rendered by making the old organizations more efficient than by organizing new ones. In accordance with this plan Clarence D. Cook was made a member of the staff July 1, 1917, and placed in charge of twelve associations. He will give them the necessary supervision to keep them in active operation and will aid in carrying out plans for making their work still more effective.

Extension Schools: Instruction was given in fourteen extension schools by the Extension Specialist in Dairying, beginning December 5, 1916, and ending March 16, 1917.

Total number enrolled	1159
Total number of lectures given	97
Total number judging demonstrations given	12

The following table gives a brief summary of the field work of the Extension Specialist in Dairying, other than in extension schools, from July 1, 1916, to July 1, 1917:

Class.	Meetings attended.	Attendance.	Meetings addressed.	Attendance at meetings addressed.
Conventions: State	2	1,250		
Local: Cow Testing Association	23	887	22	587
Local: Breeders' and Dairy Association	2		2	60
Local: Creamery	1		1	75
Local: Market Milk	1		1	150
Local: General Farmers	19	2,889	18	889
Local: Farmers' Institutes	1		1	190
Demonstrations: Judging	3		3	241
Fairs: Local	2			
Contests: Stock Judging	1	20		
Farm Visits	490			

East Lansing, Mich., June 30, 1917.

REPORT OF EXTENSION WORK IN HORTICULTURE.

BY J. H. CARMODY.

At the beginning of the fiscal year, July 1, 1916, a definite horticultural project was outlined to be followed out as closely as possible during the ensuing year. The following project was outlined in accordance with the provisions of the Smith-Lever Act:

Section 1. To demonstrate the proper methods of pruning apples, peaches, plums, grapes and other fruits at the proper season.

Section 2. To demonstrate the advantages (1) of using standard contact insecticides, (2) of spraying peaches at the proper season for Curl Leaf, (3) of summer sprays for the control of fungous disease in orchards and small fruit plantings.

Section 3. To demonstrate proper methods of grafting and top working orchards.

Section 4. To demonstrate the proper methods and advantages of thinning fruits.

Section 5. To demonstrate the proper use of cover crops in orchard practice.

Section 6. To demonstrate proper methods of packing fruits.

Section 7. To hold orchard field meetings to discuss orchard diseases and to acquaint orchard owners with the methods of control.

The work during the year has been conducted almost entirely through the County Agents. The agents are closely in touch with local conditions and as a result, the work can be performed to better advantage. Where there is no agent, as far as possible the work is conducted through some local organization such as the grange, gleaners or farmers' club.

Demonstrations are arranged as far as possible in a regular series in order to cover thoroughly the proper seasonal activities. Pruning demonstrations are given early in the spring followed by spraying, thinning, cover crops and packing where such a system can be followed. Although pruning work is one of the oldest known horticultural practices, it still seems to be the most popular phase of horticultural demonstration work.

Particular emphasis was placed, during the past year, on the subject of proper packing of Michigan fruits. Marketing and distribution looms larger in the fruit industry with each succeeding year, but the basis of the industry must always be quality and attractive packing. In this regard, a law was passed during the last legislative session providing for a standard pack of Michigan fruits.

Many requests are received for farm visitations. Visitations direct to individual farms from the office are discouraged as far as possible unless there appears to be urgent need for such a visit.

Assistance was given at seven farm schools during the winter season. At these schools a regular series of lectures pertaining to horticultural subjects was discussed. These meetings are of particular value in that they pave the way for definite demonstration work later on.

Considerable time was given during the fall months to fairs and fruit shows. Work of this nature is valuable in that it enables the Extension Specialist to keep in touch with the growers and thereby acquaint himself more closely with their many problems.

Publications and Correspondence: Correspondence in connection with the work has gradually increased as a result of wider acquaintance with the growers. Several timely articles relating to fruit growing have been published in local and state papers. A spray calendar was widely circulated, and a circular calling attention to the proper methods of preparing fruit and vegetable exhibits is ready for publication.

SUMMARY OF WORK PERFORMED.

Farm visits	202
Number of demonstration meetings	79
Attendance at demonstration meetings	1,008
Number of lecture meetings	96
Attendance at lectures	6,637

East Lansing, Mich., June 30, 1917.

REPORT OF EXTENSION WORK WITH POTATOES AND VEGETABLES.

BY C. W. WAID.

The Potato Project: The extension work with potatoes is being conducted in the form of a definite project, the objects of which are as follows:

Section I—To demonstrate the advantage of:
- (1) The tuber unit method of improving the seed.
- (2) Hill selection of tubers for seed.
- (3) Greening or green sprouting of the seed.
- (4) Seed treatment to prevent scab and black scurf (rhizoctonia).
- (5) Testing different growers' seed.
- (6) The use of commercial fertilizers.
- (7) Close planting on productive soils to increase yield and to reduce the percentage of oversized tubers.
- (8) Spraying with Bordeaux to prevent blight.

Section II—To acquaint the growers with the important potato diseases and methods of control. Also, with the approved methods of field selection of high grade seed potatoes.

Cooperation with County Agents: In each county in which a regular County Agent is employed this work is carried on in cooperation with the agent. He determines the particular sections in which the work is to be done and selects the individual growers who carry on the demonstration work and on whose farms inspection work is done and field meetings held.

Field Meetings: When the work is first started in a community one or more field meetings are held during the growing period at which the grow-

ers in the neighborhood are invited to be present. At these meetings a general talk is given along cultural lines, including the identification of insects and diseases. Control methods are also given. Such meetings are very well received as the growers are enabled to get first hand information about many things of which their knowledge is limited.

These meetings are held so far as possible on farms where one or more demonstrations are being carried on. There were fifty-seven such meetings held during the year with a total attendance of eight hundred growers.

Field Inspection: The work of inspecting certain portions of potato fields for the purpose of seed improvement was continued on the same general plan as it was conducted in 1915. Much more of this kind of work was done by County Agents during the year than heretofore. The agents having been with the Extension Specialists when the inspection work was done have become sufficiently familiar with the work to enable them to do it without the specialist being with them. Many potato growers have learned as a result of this work how to do their own inspecting.

Field Demonstrations: More and more emphasis is being placed on field demonstrations as the work is progressing. Had it not been for the war a very large number of these demonstrations would have been carried on in 1917. Even under war conditions practically every regular County Agent has been able to get a number of demonstrations started and the prospects are that much more of this work than before will be completed.

The State Potato Association: The Michigan State Potato Association has been used as a means of securing the cooperation of the potato growers of the state in the potato improvement work being carried on by the College. The annual meeting was held at Escanaba in 1916. The 1917 annual meeting will be held at the College during Farmers' Week. A potato show will, also, be held at that time.

Local Organizations: The potato development work has been carried on very largely with a view of working with groups of men rather than with individuals. Local potato associations have been maintained in many communities. In some cases the work has been carried on through an organization already formed instead of attempting to organize a potato association. The "Community Plan" of working has been the thought uppermost in the minds of those responsible for this work, whatever the method of getting the growers together.

The Vegetable Work: Because of the demand for work with potatoes the Extension Specialist has not been able to give a great amount of time to other vegetable crops. Requests for help have been taken care of either through correspondence or personal visits. The vegetable growers are, however, beginning to realize that they may secure help from the College if they make the effort. With the additional facilities for carrying on the work which we will have during the coming year much more should be accomplished along this line.

Lectures: There were fifty-two lectures given during the year at which a total attendance of 5,122 was recorded. This included the Extension Schools, Institutes and special meetings.

Farm Visits: There were 220 visits made during the year. Many of these were to call upon greenhouse men and inspect their crops. This seems to be the most practical way of helping this class of producers. At the same time these visits help to keep the Extension Specialist in

close touch with the progress of this important and rapidly developing business.

Correspondence: There has been a very great increase in the amount of correspondence during the year. This has been due in part to a wider acquaintance among potato and vegetable men. It is, also, due to the very great interest in gardening work as a result of the nation wide agitation along the line of the need of increased food production. The answering of inquiries from farmers scattered over the state is work which fits in very nicely with the Extension Visitation work.

Publications: Because of lack of funds the number of publications issued during the year has been limited. Extension bulletin No. 7, entitled "Suggestions for Growing Potatoes" has been printed. Mimeograph copies of cultural suggestions on cabbage and cauliflower growing have been made. A large number of articles have been prepared for the press and these have through the Publicity department of the College received wide distribution.

Additional Assistance Given: Because of the large amount of correspondence and office work a stenographer has been added to the force. Beginning with the next year an additional man will be employed in connection with the potato and vegetable work.

Potato Work in the Upper Peninsula: This report does not include the potato work which has been done in the Upper Peninsula. J. W. Weston has had this work in charge and his report will include his work. The potato work in the Upper Peninsula is carried on in much the same manner as in the Lower Peninsula.

East Lansing, Mich., June 30, 1917.

REPORT OF EXTENSION WORK IN FARM MANAGEMENT DEMONSTRATIONS.

BY KARL H. MC DONEL.

Farm Management Demonstrations have proved to be very successful the past year, both from the standpoint of the demonstrator and the County Agent. The account book is rapidly replacing the "Farm Record," for it is accepted by the farmer as more reliable, and the demonstrator is able to work with a greater number of farmers.

When the County Agent desires this work as a part of his year's work, publicity is given the work in the county papers, the farmer's interest being aroused as much as possible. Following this, a series of meetings is conducted throughout the area. Either the demonstrator or his assistant is present and explains the purpose and the reason for keeping farm accounts.

The account book is explained and if the farmer wants to keep the book he is given the assistance he desires to start the book, also any assistance he may ask for during the year.

At the end of the year he either summarizes his own book, or sends it in to the College where it is summarized and checked. After the figures are copied on the office sheet the book is returned to the farmer for a permanent record.

Later each farmer who sends in an account book is furnished with a report which shows him what the farm paid for his year's work, also tables and comparisons with the successful farms of that area.

If the income is low, or if it is seen by the analysis that it can be bettered, the County Agent advises with the farmer and assists him in making what changes seem necessary. This, however, is done only where the farmer asks for personal aid.

A second edition of the account book has been prepared and put into use this year. Any farmer who agrees to keep the book and turn it in at the end of the year may have one free. They are also put into the farmer's hands by the aid of the County Agent and local leaders.

The first year's demonstration has been completed in Mason, St. Joseph, and St. Clair counties. The second year's demonstration has been completed in Newaygo, Branch, and Saginaw counties.

The work has been presented by the demonstrator or his assistant in twenty-seven week schools of agriculture.

The following table gives a summary of the work during the past fiscal year:

County.	Records taken.		Records returned.		Account books.		Meetings held	Attendance.
	First year.	Second year.	By mail.	By person.	Summarized.	Started		
Allegan					1	79	13	412
Alpena					10	9		
Berrien						8	4	32
Branch				59	13	88	19	310
Cheboygan					1	90	15	200
Clinton					7	12	5	106
Kalamazoo					1	15	4	108
Kent					16	51	11	226
Lenawee					1	37	10	140
Manistee					1	86	8	167
Mason	67		67		10	17	10	150
Newaygo		86	86		39	43	8	214
Ottawa						64	5	290
Saginaw				73	38	42	6	59
St. Joseph	54			54	4	18	4	140
Shiawassee					2	18	4	124
St. Clair	66					77	12	296
Wexford					10	3		
Other areas					36	175		
Total	187	86	153	186	190	932	138	2,974

East Lansing, Mich., June 30, 1917.

REPORT OF THE EXTENSION WORK IN ENTOMOLOGY.

BY DON B. WHELAN.

The work of the Extension Specialist in Entomology has been continued along the same lines as last year. His time has been divided between the Extension work and the College. Probably a little more work has been given to the former than last year owing to the earlier closing of the College.

The work of the year may be summed up as follows:

(1) Advice and aid in combatting insect pests with demonstrations for their control. Nearly the entire state has been visited during the year and aid given by farm visits or demonstrations. Much of the work done was in response to requests for aid and for advice. One hundred and fifty-nine farms and homes were visited and demonstrations held in some of them.

No single pest stood out as doing great damage although many were present from time to time throughout the year doing more or less damage. Probably the two that gave the most concern were the Cutworm and the Pear Psylla.

A demonstration on the use of heat for controlling mill insects was put on at Hillsdale and as a result will save the millers of that mill many hundreds of dollars each year.

(2) Visiting and aiding the County Agricultural Agents.—As many of the county agents were visited as time permitted and their necessities demanded. One trip was made to the Upper Peninsula where all of the county agents were visited and aided with their insect troubles. Demonstrations were carried on with some of them.

(3) Lecturing and Extension Schools.—Fifteen lectures were given at various schools with an average attendance of forty-one. The following lectures were given: "Farm Crop Insects and Their Control," "Insects of the Garden and Their Control," "Injurious Fruit Insects and Their Control," and "Farm Methods of Controlling Insect Pests."

(4) Lectures at Granges and Other Meetings.—A lecture was given before the Grange at Manistique and before the Farmers' club at Brethren. A lecture was also given in the City Library at Menominee and others before the institute speakers at East Lansing, Boy Scouts at Manistee, Grape Growers Convention at Lawton, including an illustrated lecture before the Michigan Vegetable Growers' Association at Detroit.

(5) Attendance at State and County Fairs.—The Extension Specialist in Entomology had an exhibit of various insect pests showing the damage done by them. Questions were answered concerning many pests and how they could be controlled. The exhibit was shown at the Greenville Fair, Western Michigan State Fair, Hillsdale Fair and the Saginaw Fair. Much interest was shown at all of these places.

SUMMARY OF WORK.

	No.	Attendance.
Farms visited	160	
Demonstrations	10	95
Lectures at Farm Schools	15	615
Lectures at Other Meetings	13	369
Fairs attended	4	

East Lansing, Mich., June 30, 1917.

REPORT OF EXTENSION WORK IN HOUSEHOLD ENGINEERING.

BY O. E. ROBEY.

The work in Household Engineering has been carried on in practically the same manner as in the previous years. It is encouraging to note that there is a growing interest in home improvement in the country. A number of forces are assisting along this line. Several firms are actively engaged in selling water systems, lighting plants, and other equipment which help in improving home conditions. The automobile has had an educational effect; it has widened the field of observation and brought the farmer in contact with city conditions.

The work under this project has been carried on long enough to begin to show results. For instance, one community in Kent county where the writer explained the construction of a septic tank three years ago, has now installed twenty-five tanks.

In order to determine whether our type of septic tank has proven satisfactory, a circular letter was sent to a number of people who have had them installed; practically every one replied. All reported that the tanks have given no trouble. The following quotations taken from some of the letters would seem to indicate that the work is appreciated:

"I consider this system of sewage disposal a necessity for the country home and the cost not excessive in any way."

"I have not had any trouble; I think the system perfect."

"It is my belief that if farmers generally realized the comfort and health safe guard that your septic tanks really are, the farm home without one would be the exception, rather than the rule as at present."

The work of the year has been divided as follows:

Extension Schools, Round-Up and Conference	14 weeks
Fairs	5 weeks
Preparation of literature	5 weeks
Drainage	3 weeks
Household Engineering, Field and Office Work	21 weeks
	48 weeks

Extension Schools: Lectures similar to those given last year were delivered at thirteen one-week schools. Practically 400 people attended the lectures.

Fairs: A small exhibit showing a septic tank and the installation of a water system was put on at the Grand Rapids, Greenville, Saginaw and Hillsdale Fairs. A great deal of interest was shown; hundreds of people asking for information.

Publications: It is unfortunate that the bulletins already prepared have not been published. We have had a great many demands for them. A bulletin on "Water Supply" has been prepared and will be ready to present as soon as a few drawings are completed.

Drainage: Since the declaration of war it seemed a patriotic duty to give assistance along production lines should the opportunity present itself. Farm drainage is a limiting factor in production in a great many places. Practically three weeks have been spent in laying out drains, planning drainage systems and giving information along drainage lines. This work has been particularly important owing to the wet season.

Household Engineering Field Work: Twenty-two weeks were devoted to this work. Besides the regular office work and a small amount of experimental work, during this time 74 farms were visited and assistance given. Assistance was given in the construction of 24 septic tanks and seven lectures were delivered to approximately 300 people.

East Lansing, Mich., June 30, 1917.

REPORT OF EXTENSION WORK IN FORESTRY.

BY E. C. MANDENBERG.

The present Extension Specialist has been carrying on the work in Forestry Extension since October, 1916. Previous to this time the members of the Forestry department staff carried on the work of this project. Demonstrations of the following nature were held:

1. *Plantings to hold the light, shifting, sandy soils:* Eighteen thousand willows and several thousand locust tree seeds were planted on Big Prairie in Newaygo county. This is one of the worst blow sand areas in the state and we hope this planting will hold the sand and that we will eventually get it under forest cover. Another bad sand blow was planted in Holland Township, Ottawa county. This blow covers about 12 acres and it has completely filled up a county drain causing water to back up on 4,000 or 5,000 acres of fertile land. Two planting bees were held and thirty thousand willow and poplar cuttings were set. We are also trying out some chick peas, furnished by the United States Government, some lupines, soy beans and cow peas on this sand. Still another blow covering several acres was partially covered in Kalamazoo county.

2. *Management and care of farm woodlots:* At these demonstrations we tried to show farmers what trees should be cut when thinnings are made, what kind of materials should be cut from them, how woodlots of hard maple should be managed for sugar and syrup production, and how to estimate the amount of timber standing on the woodlot.

3. *Culture of basket willows:* Several small plots and one large plot were established. A splendid market has opened up for native willows and more farmers will be urged to plant them.

4. *Beautification of the home and country school grounds:* Plans have been made and carried out. There is a big field for this kind of extension work.

5. *Christmas tree planting for city markets:* A 10 acre mixed planting of poplar and spruce was made near Nunica. There seems to be a big demand for home grown Christmas trees and plantations are being put in all over the state.

6. *Roadside tree plantings:* A planting of roadside trees was made on a mile and a half of road near Howard City. This phase of the work should be pushed the coming year.

7. Meetings were held with the maple syrup and sugar makers in various parts of the state and the Michigan Maple Syrup Makers' Association was organized. The object of this association was to encourage better and more economical methods of producing pure, high grade Michigan maple syrup, to make better and more uniform grades of syrup, to assist in advertising and marketing the product and to aid the syrup maker in solving his problems. It has a membership of 60 farmers and nearly all of these men were given some assistance in their sugar camps.

SUMMARY.

	No.	Total Attendance.
Farm visits	172	
Demonstrations held	20	142
Visits to buyers of products	64	64
Conferences with County Agents	28	28
Lectures given	10	410
Schools visited	22	
Counties visited	40	
Farmers assisted in woodlot marketing	47	47
People served (mostly farmers)		1,121

East Lansing, Mich., June 30, 1917.

ANNUAL REPORT OF THE OFFICE OF MARKETS.

To the State Board of Agriculture:

I beg to submit the following report of investigations and work of the Michigan Office of Markets for the year ending June 30th, 1917.

As to whether the markets office should be connected with other agricultural activities of the state has been answered in the affirmative by about three-fourths of the states adopting the Michigan plan of coordinating with the State Agricultural College.

Marketing is one of the most complex of human relations and the best constructive thought of the nation has been devoted to investigation and outlining marketing procedure. The association of federal and state activities provides a corps of men including county agricultural agents, special agents of the markets office here and at Washington, and others, which is a combination for service that is of advantage, because commerce is no longer thought of in state line boundaries.

The tentative legislation to states not already having marketing laws as recommended by the United States Bureau of Markets, is that of the Michigan outline. Partisan political bias which has been the occasion of much bitterness in several states has been avoided. There is not so much opposition to marketing reforms and better service as lack of working plans therefore.

The advocacy of cooperation and the refusal to cooperate with all the agencies of the state and nation is a limitation resulting from limited information.

Much confusion arises from the failure to classify farm products as those whose form must be changed before consumers use, and those in form such as the citrus fruits which are susceptible of successful direct marketing. The great farm staples such as grain, textiles, meats, and a large portion of the fruits and vegetables have to be manufactured or put through a process before they are ready for the consumer. An examination of the stocks found in retail grocery stores usually discloses that 90% of the goods are changed in form by manufacturing and approximately 10% have not been. When the producer has parted with the raw material that reappears as butter, cheese, canned goods, cereals, cured meats, soap, etc., etc., he has sold these products as raw material. When these are aggregated, and with these are associated say 10% in value of potatoes, vegetables, etc., to be sold in the form produced, the question arises at once as to whether the sale of the last named in association with the manufactured goods is not perhaps as economical in distribution as if sold directly alone. The agency of direct marketing is open to everyone who has goods to sell and can find a buyer. All established city markets are at his disposal. All these fields have been cultivated by the United States in the possible service to be rendered by the parcels post. The various express companies have endeavored to handle and build this trade at no cost but that of transportation. In spite of all this, the volume is small and is a negligible factor at present. The experience of individual cooperative associations and even the activities of the states have not found direct marketing successful. The wholesale grocer is in one sense like the producer in having goods for sale. With standardized goods, credit reports and all the machinery of business, he has not been able to dispense with salesmen. The best information obtainable indicates that it is possible to market less than ten per cent of farm grown products directly, and this amount in practice is decreased because of remoteness from market and because of small units.

While perfection is far away, it does not seem good marketing marksmanship to devote overmuch effort on the smallest units of output. Unorganized agriculture is individually selling unappraised products, to a well posted body of buyers. Efficiency in buying so as to increase the profits is a part of the organization of buyers. Edwin Hurley of the Federal Trade Commission has pointed out that the greatest menace to business is the business man who does not know what it costs to do business. Agriculture being basic, in the sense of the starting point for so much of manufactured goods, has wide variations as to unit or pound or bushel cost. Seasonable variations are influences to be reckoned with. The acre cost in agriculture is an easier measure to the farmer, of cost, and less variable, but an unknown and impossible standard for the buyer to use. It is this lack of common meeting grounds for the producers to act as a unit and the different denominators of cost measure, which to the grower

is the acre, and to the buyer, the pound, that men's minds do not meet. The great service that a Market Office then can do, is to assist the producer to aggregate with those of his class, and provide the best information that is obtainable as to supply and demand, and the cost of unit to be sold. This is in short, to place agriculture upon the same plane with the buyer, in the interpretation of supply and demand in terms of price. The ambiguity of the more usual terms of agriculture, such as increased efficiency, reducing the cost, cooperation, standardization, etc., are not possibilities for meeting points for men's minds. The statutes of the United States against trade restraints center around the psychological fact of a common understanding of values. The commerce of the world is expressed in money, the common denominator of exchange values, Agriculture as an organic industry, has rarely used the measure of value upon its own output. The proclaiming of agricultural cooperation without a common meeting point of men's minds engaged in the industry, has made this work an unstable guide, and deprived of leadership. Uncooperating units of agriculture were impotent to deal with buyers who possessed the knowledge of the factors that determined values.

This was then, the condition of the marketing of beans in Michigan prior to organization of the growers. It is not the purpose of the Markets Office to fix prices or promulgate values. It is however, the duty of this office to supply the advices that informs of the factors which men's minds demand, to act intelligently. The reforms in and advices for the marketing of Michigan's bean crop in 1916, placed between two and three million more of money into the hands of the bean growers, than would have otherwise been done, is the opinion expressed by leading elevator operators in this state. This service was not confined to state lines, but the State Market Director of Idaho advises that this same information from Michigan raised the price on one hundred and fifty carloads of beans in that state, two cents per pound in twenty-four hours. New York, Colorado, Idaho and Ontario have planned their marketing of beans in the future, in the manner set by Michigan. It was the satisfaction of the marketing of the Michigan bean crop of 1916 that made it easy for the bean growers to vastly increase the acreage for 1917, when the nation's needs were never greater. The cooperation of bean growers and buyers in deliberations as to the growing and handling of the crop, is one of the most hopeful commercial conditions. Cooperation confined to a class, is narrow, and tends to hostility rather than to mutual service. The authorization of the investigation and improvement of the marketing of beans in this state, by the State Board of Agriculture in advance of any legislation, was an advanced step in coordinating production with distribution.

The Michigan Milk Producers' Association was organized at the Agricultural College, and has united an industry as no other agricultural body in the state, in the sense of maintaining a paid field agent and the expenses of campaigns for improvement of prices and products. The rapid advances in feedstuffs made the price schedules that seemed adequate for milk, entirely inadequate a month later. In many places their schedules of prices were advanced to meet at least in part, increased cost of milk production. Measured in money, the work of the Milk Producers' Association is reckoned by R. C. Reed, the efficient field secretary, as increasing the yearly earnings of every man whose daily output of milk is 250 pounds, over $400. It was the leadership of the Michigan

Milk Producers' Association, that, in the persons of Milo Campbell and N. P. Hull, shaped the plans of the National Organization of Milk Producers in December of 1916.

The Federated and Federation of Fruit Growers in Michigan have pursued in a similar manner, the plans of interpreting supply and demand in terms of value. Where there was little union, there have now sprung up, strong bodies of fruit men working together. The services and counsels of men of the type of George E. Prater and R. H. Morrill, have been invaluable in this work.

When the question of minimum price control was first urged, the Markets Office made inquiry of 200 farmers and business men of Michigan, and transmitted a summary to Senator William Alden Smith. This report was published verbatim in the Congressional Record, as an expression of Michigan sentiment.

The enactment of the Clayton Amendment to the Sherman Anti-Trust Law with agricultural organizations exempted when not organized for profit and not having capital stock, has been a reason for the effort to secure organizations of cooperative bodies under the Act of 1903. The reason for the exemption of agricultural organizations is not one of political favoritism but because, when the profits of agriculture are returned to the producer on the basis of his product, rather than upon his ownership of stock, then the line is clearly drawn between the possibilities of agricultural cooperation and exploitation. The United States has recommended that a similar cooperative Incorporation Act, to that of Michigan be enacted in all states. A distinction is drawn between capital and capital stock. Stock implies control through ownership. Capital derived from membership fees and individual credit loaned to the association, maintains the distinction the law makes between cooperative and other corporations. The federation of corporations organized under other statutes, or when these affiliate or act in any capacity together places them in technical violation of the Federal laws. An example of the most modern cooperative body is that of the Plymouth Cooperative Association. The capital when needed, is loaned by the banks, by each member giving a non-interest bearing collateral note for $35.00. The profits of the transaction eventually discharge the loans. These notes, good for three years, are ready collateral for use, the same as the city investor borrows on stocks or bonds as collateral. From a banking standpoint, the security is good. This is the Danish method of cooperating credit, which is always more plentiful than cash. Cooperative Associations, seeking a model, might well pay a visit to the Plymouth body. There are large savings possible in the purchase for cash of all farm supplies as well as actual manufacturing and selling. Wherever there has been a call for various cooperative bodies, the Markets department has been at their service.

In the matter of statutory regulation of trade, the Markets Office is averse to the employment of police powers as a part of its prescribed duties. There are other departments of the state which are in need of this power and where its enforcement can best be accomplished. In marketing much of the unmerchantable products which are at the same time wholesome and of great food values could well be taken off the market by drying. An established plant to make potato flour would allow commercial grading of potatoes without the ever present twilight zone of the unmerchantable.

The services of R. H. Elsworth as assistant State Marketing Director, and Federal Field Agent in Marketing, have been most gratifying. The cooperative work is detailed below.

During the eight months ending with June 30, 1917, field work in marketing has been carried on in 34 of the 83 counties in Michigan. Many additional counties have been reached by correspondence or through the County Agricultural Agents.

The accomplishments and the activities of the Field Agent in Marketing, recorded under project titles are as follows:

Organization: Assistance has been given in the orgnaization of seven standard cooperative buying and selling associations. These associations are organized in accordance with Section 6 of the Clayton Anti-Trust law.

Allegan County—Saugatuck, Saugatuck Cooperative Fruit Association.

Alpena County—Ossineke, Ossineke Cooperative Association (livestock, hay, grain).

Barry County—Hastings, Central Barry Cooperative Association (livestock).

Cressey, Southern Barry Cooperative Association (livestock).

Berrien County—Benton Harbor, Benton Center Fruit Association (fruit).

Coloma, Berrien County Fruit Association (fruit).

Mecosta County—Barryton, Barryton Cooperative Association (livestock).

Assistance was given in the matter of organizing the Grand Rapids Dairy Company (Kent county). This company is incorporated under Act No. 398, Public Acts (Michigan) of 1913. It is semi-cooperative with a capital stock of $75,000, of which amount $50,000 is already subscribed. The statute provides for suitable reserves, six per cent dividends to capital stock, and then patronage dividends. The company is formed to market the milk of its four hundred members at wholesale and retail in the city of Grand Rapids.

Assistance was also given in the work of re-organizing eight existing associations and re-drafting their organic laws that they might incorporate as non-capital stock, non-profit associations. The associations are:

Berrien County—Bridgman, Bridgman Fruit Growers' Association (fruit).

Millburg, Millburg Fruit Growers' Association (peach).

St. Joseph, St. Joseph-Michigan Fruit Association (grapes).

Mecosta County—Big Rapids, Farmers' Cooperative Creamery Association (creamery).

Muskegon County—Muskegon, Muskegon-Grand Haven Celery Growers' Association (celery).

Van Buren County—Lawton, Southern Michigan Fruit Association (grapes).

Paw Paw, Fruit Growers' Union (grapes).

Paw Paw, Wolverine Fruit Association (grapes).

Aid has been given in the formation of two federations of fruit shipping associations. They are:

Michigan Fruit Packers' Federation.
Michigan Grape Growers' Federation.

The purpose of the federations is to disseminate information regarding marketing conditions, bring about higher standards in the grading and packing of fruit, and endeavor to cause an increased demand for Michigan fruits.

Temporary organizations, which may in time become permanent selling associations were formed as follows:

Antrim County—Bellaire (fruit).
Alpena County—Wilson Community (grain, hay, livestock).
Barry County—Freeport (grain).
Livingston County—Howell (feed, coal, livestock).
Oceana County—Hart (fruit).
Van Buren County—Breedsville (fruit).

Informal talks regarding organization problems, in addition to the many and long talks in connection with the formation of the above enumerated organizations, were given as follows:

Allegan County—Martin (general).
Benzie County—Beulah (fruit).
    Frankfort (fruit).
Berrien County—Millburg Church (general).
Eaton County—Grace Church (livestock).
Grand Traverse County—Traverse City (fruit).
    Long Lake Grange (general).
Ingham County—East Lansing (general).
Kent County—Grand Rapids (dairy products).
Lenawee County—Adrian (general).
Mason County—Victory Town Hall (creamery).
Manistee County—Onekama (raspberries).
Mecosta County—Big Rapids (fruit).
Midland County—Coleman (livestock).
Oceana County—Shelby (fruit).
Ottawa County—Jamestown (grain).
St. Clair County—Capac (general).
    Columbus Hall (general).
    Bethel Church (general).
Van Buren County—Decatur (celery).
    South Haven (fruit).

The Field Agent attended and spoke at the meeting of the Executive Committee of the Michigan State Grange at Jackson (Jackson county) at which the topic of "Organization for Cooperative Marketing" was discussed at length.

The status of the Northport Fruit Growers' Association (Leelanau county) was discussed with the secretary of that organization.

A meeting was held with the potato growers of Wolverine (Cheboygan county) and their organization problem discussed at length. They were urged to form a non-capital stock, non-profit, organization to handle their collective business transactions.

Market Business Practice: A vast amount of preliminary work preparatory to the introduction of the uniform systems of accounting devised by the Bureau of Markets has been carried on in the state.

Informal audits were made of the 1916 business of the following organizations:

Allegan County—Fennville, Fennville Fruit Exchange (fruit).
St. Joseph County—Burr Oak, Burr Oak Cooperative Association (livestock).
Van Buren County—Bangor, Bangor Fruit Growers' Exchange (fruit).

The accounting systems in use by three grain elevator companies were critically examined. The elevators were:

Ionia County—Lake Odessa, Farmers' Grain & Produce Co.
Mecosta County—Rodney, D. Mansfield & Company.
Saginaw County—Merrill, Merrill Farmers' Elevator Co.

Three creameries are preparing to install the uniform system devised by the Bureau of Markets for country creameries. They are:

Barry County—Delton, Delton Cooperative Creamery.*
Hillsdale County—Litchfield, Litchfield Dairy Association.
Kent County—Caledonia, Caledonia Cooperative Creamery.*

Four fruit shipping associations have ordered the uniform system of accounts devised by the Bureau of Markets for fruit and produce organizations. The associations are:

Allegan County—Saugatuck, Saugatuck Cooperative Fruit Association.
Berrien County—Benton Harbor, Benton Center Fruit Association.
Coloma, Berrien County Fruit Association.
Millburg, Millburg Fruit Growers' Association.

The first two named organizations are now installing the system.

Formal conferences regarding accounting matters were held with the officers or employees of seven organizations as follows:

Barry County—Hastings, Central Barry Cooperative Association.
Middleville, Middleville Cooperative Co-Partnership Creamery Company, Ltd.
Hillsdale County—Litchfield, Litchfield Dairy Association.

*Not yet visited by Field Agent.

Kent County—Alto, Alto Co-operative Creamery Association, Ltd.
Grand Rapids, Grand Rapids Dairy Company.

Van Buren County—Bangor, Bangor Fruit Growers' Exchange. (meeting with members of Board of Directors).

Wayne County—Plymouth, Plymouth Agricultural Association.

In several cases more than one visit has been made to an association in an effort to render service.

Fruit Grading and Standardization: Preliminary work in behalf of the standardization of Michigan fruits was carried on at Grand Rapids, Benton Harbor, Hartford and Lansing. At the first named place the Field Agent drafted resolutions which were laid (by C. B. Cook) before the Michigan State Horticultural Society, December 5, 6 and 7. At Benton Harbor (Michigan State Horticultural Society, February 20 and 21) the Field Agent in Marketing acted as chairman of a committee to report upon proposed apple grading legislation. At this meeting the Michigan Fruit Packers' Federation was brought into existence and subsequently did excellent work for standardization. At Hartford, February 28, the Federation directed its secretary to visit the State Capitol and urge the desired legislation. The meeting at Lansing, March 8, was a hearing before the horticultural committees of the two branches of the legislature in connection with the proposed fruit grading bills. The program adopted on this occasion was carried through. Three Michigan fruit standardization laws were enacted by the legislature.

Act No. 74, Public Acts of 1917, is the same as the federal act to fix standards of climax baskets.

Act No. 75, Public Acts of 1917, is in accordance with suggestions made by the Fruit Standardization project, Bureau of Markets, for an apple grading law.

Act No. 88, Public Acts of 1917, is the same as the federal act defining "standard barrel for fruits, vegetables, etc."

These acts go into effect about August 20, 1917.

As a direct result of the passing of the fruit grading laws the Michigan Dairy and Food Commissioner has appointed a fruit inspector, Leslie Scott, Bangor, Mich., who will devote his entire time to the enforcement of the above and similar laws.

The Michigan Fruit Packers' Federation at its meeting at Hartford June 14, adopted the following peach grades and sizes for 1917:

B grade—1½ to 1⅞ inches
A grade—1⅞ to 2¼ inches
AA grade—2¼ inches and up.

Eleven associations hold membership in the federation.

Informal talks bearing upon standardization were made, in addition to the above mentioned work, at meetings as follows:

Benzie County—Frankfort.
Berrien County—Benton Harbor.
Mason County—Ludington.
St. Clair County—Bethel Church.

City Marketings: Observations were made at the following markets:

Grand Traverse County—Traverse City (potato).
Ingham County—Lansing (municipal).
Jackson County—Jackson (municipal).
Kalamazoo County—Kalamazoo (municipal).
Kent County—Grand Rapids (municipal, two).
Manistee County—Manistee (municipal).
Mecosta County—Greenville (potato).

During the winter data were collected by means of questionnaires and observations upon the chances of establishing successful public markets in Adrian and Muskegon.

Informal talks bearing upon value and operation of public markets were made before the Muskegon County Horticultural Society and the vegetable growers of Jackson (Jackson county).

Market Surveys: Many places were visited for the purpose of observing various phases of the marketing problem.

The wholesale fruit and produce sections of Bay City, Bay county, and Saginaw, Saginaw county, were visited.

The canning plant at Cherry Home Orchards near Northport, Leelanau county, was visited.

An afternoon was spent in studying grain marketing at the elevator of the Chesaning Farmers' Elevator Company, Saginaw county.

Observations as to the methods of marketing dairy products were made as follows:

Berrien County—Benton Harbor, Twin City Creamery Company.
Eaton County—Charlotte, Dry Milk Company.
Kalamazoo County—Kalamazoo, Dairymen's Milk Company.
Oakland County—Pontiac, Pontiac Creamery Company.

Live Stock marketing was studied in connection with the following enterprises:

Branch County—Batavia, Batavia Cooperative Company.
Coldwater, Coldwater Cooperative Company.
Quincy, Quincy Shippers' and Buyers' Association.
Wayne County—Detroit, Central Live Stock Yards.

Miscellaneous Activities: Six informal talks under the title, "Advertising to Increase Consumption of Farm Products" were given as follows:

Berrien County—Benton Harbor.
Benzie County—Frankfort.
St. Clair County—Capac.
Columbus Hall.
Van Buren County—Hartford.
South Haven.

Informal talks upon the general subject, "The Marketing of Farm Products" were given at meetings of commercial organizations as follows:

Eaton County—Eaton Rapids, commercial organization.
Mason County—Scottville, commercial organization.
Manistee County—Manistee, business men's noon luncheon.
Mecosta County—Big Rapids, group of bankers.

Participated in formal conferences as follows:

Branch County—Coldwater, Committee Milk Producers' Association.
Coldwater, Branch County Cabbage Growers' Association.
Ingham County—Lansing, Michigan Agricultural Development Association.
Manistee County—Bear Lake, Northern Michigan Agricultural Congress.

Many informal conferences were held with W. B. Liverance, manager, Michigan Cooperative Association of Creameries, Grand Rapids, Kent county; H. D. Wendt, dairy division, Michigan Dairy and Food Department, Lansing, Ingham county, and Hon. James N. McBride, Michigan Director of Markets, East Lansing, Ingham county.

A considerable amount of committee work was done in connection with the different meetings attended and an extensive correspondence was carried on with persons in all parts of the state.

JAMES N. MC BRIDE,
Michigan Director of Markets.

R. H. ELSWORTH, Assistant.

East Lansing, Mich., June 30, 1917.

THIRTIETH ANNUAL REPORT

OF THE

EXPERIMENT STATION

OF THE

Michigan Agricultural College

UNDER THE HATCH AND ADAMS ACTS

FOR THE

YEAR ENDING JUNE 30, 1917.

For members and organization of the State Board of Agriculture in charge of the Station and list of officers, see page 15 of this volume.

REPORT OF SECRETARY AND TREASURER.

The following shows the receipts and disbursements of the Experiment Station for the year ending June 30, 1917:

		Dr.	Cr.
July 1, 1916.	To balance	$6,984 31	
Aug. 18, 1916.	received from U. S. Treasury	7,500 00	
Oct. 12, 1916.	received from U. S. Treasury	7,500 00	
Jan. 15, 1917.	received from U. S. Treasury	7,500 00	
April 16, 1917.	received from U. S. Treasury	7,500 00	
June 30, 1917.	license fees, 350 brands commercial fertilizers	7,000 00	
	license fees, 490 brands commercial feeding stuffs	9,800 00	
	farm and miscellaneous receipts	327 43	
	from State appropriation, South Haven Experiment Station	2,000 00	
	from State appropriation, U. P. Experiment Station	5,000 00	
	from South Haven Experiment Station receipts	170 77	
	from U. P. Experiment Station, receipts	4,608 41	
	from State Treasurer 1-5 mill	15,000 00	
	By disbursements as per vouchers filed in the office of the State Auditor General	....	$81,406 80
	balance overdrawn	515 88	
	Total	$81,406 80	$81,406 80

Fifty thousand regular bulletins No. 276; fifty thousand regular bulletins No. 277; fifty thousand regular bulletins No. 278; seven thousand five hundred special bulletins No. 80; twenty-five thousand circular bulletins No. 31; twenty-five thousand circular bulletins No. 32; five thousand technica bulletins No. 28; five thousand technical bulletins No. 29; five thousand technical bulletins No. 30; seven thousand five hundred technical bulletins No. 31; seven thousand five hundred technical bulletins No. 32; seven thousand five hundred technical bulletins No. 33; seven hundred reprint press bulletins No. 37; one thousand press bulletins No. 50; one thousand five hundred press bulletins No. 51; two thousand press bulletins No. 52; two thousand five hundred press bulletins No. 53; two thousand press bulletins No. 54; two thousand press bulletins No. 55; one thousand five hundred press bulletins No. 56; one thousand press bulletins No. 57; one thousand five hundred press bulletins No. 58; one thousand press bulletins No. 59; seven hundred press bulletins No. 60; seven hundred press bulletins No. 61; seven hundred fifty press bulletins No. 62; have been issued by the Experiment Station during the fiscal year.

DISBURSEMENTS ON ACCOUNT OF U. S. APPROPRIATIONS.

	Hatch fund.	Adams fund.
Salaries:		
Director and other administrative officers	$2,020 00	....
Scientific staff	2,575 00	$800 00
Assistants to scientific staff	4,639 80	9,083 20
Labor:		
Annual and monthly employees	688 00	902 00
Balance by week, day and hour as needed	969 80	1,267 59
Publications:		
Other expenses (copper half-tones)	21 08	....
Postage and stationery:		
Postage	66 44	2 42
Stationery	18 51	13 50
Telegraph and telephone	26 76	1 30

DISBURSEMENTS ON ACCOUNT OF U. S. APPROPRIATIONS.—*Continued.*

			Hatch fund.	Adams fund.
Freight and express			$33 18	$0 69
Heat, light, water and power:				
Heat			252 80	
Chemicals and laboratory supplies:				
Chemicals			308 74	296 38
Other supplies			556 34	328 08
Seeds, plants, and sundry supplies:				
Agricultural			54 80	
Horticultural			99 13	
Botanical			103 92	91 36
Entomological			24 15	16 48
Bacteriological			4 83	17 52
Chemical			9 12	12 99
Soils			97 29	55 15
Fertilizers			273 20	
Feeding stuffs				537 25
Library:				
One copy American Journal of Physiology			15 00	
One copy Berichte der Deutschen Chem. Gasellschaft			15 00	
One copy Chemisches Centralblatt			20 00	
Three copies Chemisches Journal			12 60	
One copy Archiv der Hygiene			7 50	
One copy Journal of Royal Soc. of Chem. Ind			9 50	
One copy Journal of Royal Microscopical Soc			9 00	
One hundred seventy-three vol., one-half morocco bound			198 95	
One copy Genera Insectorium			19 25	
One copy Vet. Obstetrics			8 00	
One copy Report 10th International Vet. Congress				7 18
One copy Infection Immunity and Spec. Theropy				6 00
Two copies Centralblatt fur Bateriologie			14 40	
One copy Hygienesche Rundschau			7 00	
One copy Centralblatt fur Bateriologies			7 20	
One copy Zeitschrift fur Chem			9 12	
Other purchases			182 97	2 15
Tools, machinery and appliances:				
(a) New purchases			127 19	17 19
Repairs			33 27	14 10
Items of principal purchase:	Hatch.	Adams.		
One sifter and mixer	$40 06			
One Harrowless Ent. Frame	38 00			
One Nusystem gun	15 00			
One Nusystem gun B	15 00			
Seventy ft. ½ in. br. hose, fitted	15 30			
One wheelbarrow		$3 75		
One screen cage		11 04		
Furniture and fixtures:				
One thermometer cage				4 28
One No. 1070 filing cabinet			29 80	
Scientific apparatus and specimens:				
Six triple aplanat			19 02	
One fireless electric oven			165 00	
Two Beckman thermometers			30 00	
Two Beckman thermometers			30 04	
One pressure cooker			26 00	
One No. 21340 Troemner balance and weights			73 85	
One hygrograph				45 00
Two four condenser stills				68 00
One balance				100 00
One No. 30 electric centrifuge				25 00
Four Beckman thermometers				95 12
One centrifuge 220 v				180 77
Twenty picnometers				56 54
Two sets analytical weights				38 00
One direct reading ionometer				303 00
One electric hot plate				15 00
Other purchases			59 84	217 33

DISBURSEMENTS ON ACCOUNT OF U. S. APPROPRIATIONS.—*Concluded.*

	Hatch fund.	Adams fund.
Live Stock:		
Small experimental animals	$27 80	$193 99
Traveling expenses:		
In supervision of station work	344 54	....
In connection with investigations under Adams Act	....	69 36
For other purposes connected with station work	635 27	....
Contingent expenses:		
One year's dues, 1916-1917, Association of American Colleges and Experiment Stations	20 00	....
Buildings and land:		
Improvements	....	116 08

DISBURSEMENTS OF EXPERIMENT STATION MONEYS—OTHER THAN RECEIVED FROM U. S. TREASURER.

Salaries	$26,470 33
Labor	10,096 23
Publications	46 43
Postage and stationery	448 73
Freight and express	319 45
Chemicals and laboratory supplies	874 30
Seeds, plants and sundry supplies	3,223 00
Fertilizers	107 77
Feeding stuffs	2,616 50
Library	28 93
Tools, machinery and appliances	728 02
Furniture and fixtures	78 47
Scientific apparatus and specimens	99 67
Live stock	2,137 18
Traveling expenses	3,852 08
Contingent expenses	5 00
Buildings and land	274 71
Balance overdrawn	515 88
Total	$50,890 92

REPORT OF THE DIRECTOR OF THE EXPERIMENT STATION.

To President F. S. Kedzie:

It is a pleasure to be able to report to you that another year's work of the Experiment Station has been completed in a satisfactory way. Without exception the individuals of the organization have worked patiently, persistently and harmoniously, despite the fact that the financial status did not permit of material increases in salaries or funds for conducting investigations. As the section reports are in most instances quite complete, I have little to add at this time, but hope during the ensuing year to be able to prepare for publication, a manuscript of general information on the work of the Experiment Station.

The developments of the Extension division are adding greatly to the demands upon the Station. County Agents and specialists were greatly increased in number during the year both by automatic appropriation increases and because of war emergency needs. The Extension men are

being constantly confronted by problems of an almost endless variety requiring investigation by the Station. We feel the future welfare of Extension work will be dependent in large measure, to increased appropriations by the state, to increase the scope and to further stimulate the activities of agricultural investigational work.

We now have a large well classified mailing list, with modern machinery, for issuing publications rapidly. The following comprises the classified list:

Michigan (Lower Peninsula)	35,000
Michigan (Upper Peninsula)	1,000
Other States	2,000
Libraries, Schools, etc.	1,050
Firms	250
Foreign	200
Extension Workers	150
Press (Michigan)	530
Press (Other States)	200
Official	2,000
Total	42,380

Because of the general financial status it was not possible to issue all publications desired during the year. The demand for information has been met in part, however, by supplying those listed with some of the popular publications issued by the Extension division.

The various funds of the Experiment Station were apportioned during the year as follows, viz.: Hatch fund salaries, $9,234.80; operating expenses, $5,765.20. Adams fund, salaries, $9,735.80; operating expenses, $5,264.20. The total state funds expended during the year amounted to $35,974.21, including $15,000 appropriated directly by the State Board of Agriculture, the balance of $20,974.21 being derived from license fees and sundry receipts. For the work of the Upper Peninsula Station at Chatham $12,362.67 was appropriated from the current funds of the College and for the South Haven Sub-Station the sum of $3,069.92. The total expenditures of the Experiment Station for the year, therefore, amounted to $81,406.80, exceeding the funds used the preceding year by $9,734.30, derived almost entirely from increased receipts from fertilizer and feeding stuffs inspection work.

There are three exceedingly important lines of investigational work which should be stimulated and developed immediately. One of these pertains to animal and dairy husbandry feeding investigations and another relates to land reclamation by drainage. There are numerous problems in farm mechanics, relating to buildings including lighting, heating, sanitation conveniences, etc., as well as fencing, farm machinery and other problems upon which information is desired, which can be supplied only after careful investigation and an additional appropriation of several thousand dollars would be needed to procure necessary men and funds with which to carry on the work.

The following is a list of the publications of the Station for the year:

Popular:
- 276—Commercial Feeding Stuffs.
- 277—Studies in Cost of Market Milk Production.
- 278—Fertilizer Analyses.

Circular:
- 31—Red Rock Wheat.
- 32—Barley Improvement.

Special:
- 80—Yellow Rocket.
- 81—Tomato Leaf Spot.

Technical:
- 28—The Soil Solution Obtained by the Oil Pressure Method.
- 29—Cream Ripening and Its Influence.
- 30—Pasteurization and Its Influence.
- 31—Further Studies of the Freezing Point.
- 32—The Transmission of Bact. Abortus (Bang) to New Born Calves Through the Ingestion of Milk.
- 33—A Study of the Presence of Bacterium Abortus (Bang) in Milk.

Press:
- 50—Rye Smut.
- 51—The Pear Psylla.
- 52—Suggestions for the Control of Foul Brood Among Bees.
- 53—Pure Cultures for Legume Inoculation.
- 54—The Early Preparation of Bee Suppliers.
- 55—The Extent of the Bee Diseases in Michigan.
- 56—American Foul Brood a Disease of Bees.
- 57—Money in Forest Planting.
- 58—The Cherry Leaf Beetle.
- 59—European Foul Brood and Italian Bees.
- 60—Small Potatoes for Seed.
- 61—Caution Against the Use of Frosted or Chilled Potatoes for Seed.
- 62—Greater Efficiency in Bee Keeping This Year.

Respectfully submitted,

R. S. SHAW,

Director of Experiment Station.

East Lansing, Mich., June 30, 1917.

REPORT OF BACTERIOLOGIST.

Director R. S. Shaw:

Dear Sir—In my annual report for the previous year there were outlined the projects under investigation in this laboratory. There have been no changes in the general plan during the present year.

Mr. Cooledge reports on his Adams project, *Ia*, as follows:

"One third of my time during the past year has been given to technical research (Adams). I have continued my studies upon my general problem, "Effect of Disease in the Cow on the Milk." Additional facts which have developed in this work are embodied in the following papers and published articles:

Further Studies upon *Bact. abortus* Infected Udders.
Presented at the meeting of the Section of Sanitary and Medical Science of the Michigan Academy of Science, March, 1917.

A Study of the Milk in Bovine Infectious Abortion.
By Ward Giltner, L. H. Cooledge, and I. F. Huddleson. Presented at the meeting of the American Veterinary Medical Association, Detroit, Michigan, August 22, 1916. Published in the Journal of the American Veterinary Medical Association, November, 1916.

The following articles have been submitted for publication:

Facts Disclosed in a Study of the Presence of *Bact. abortus* (Bang) in Milk by Means of the Agglutination Test, to the Journal of Medical Research.

A Study of the Presence of *Bact. abortus* in Milk, as Technical Bulletin 33, from this Station. (L. H. Cooledge.)

MILK CONTESTS IN MICHIGAN.

The work supported by Hatch and State funds done under Mr. Cooledge's direction is as follows:

"One third of my time during the past year has been given to work of a popular nature, (Hatch). This work has consisted in examination of samples of milk submitted to the laboratory for examination, correspondence with dairymen along the line of dairy hygiene and the judging of milk contests.

"A milk contest was judged for the Highland Park Board of Health in December. While this was the first contest to be held by the village the samples of milk scored very high. This is probably because many of the farmers in this section have profited by entering the numerous milk contests that have been conducted by the Detroit Board of Health and by the State Fair Association, and because Detroit and Highland Park milk inspectors have been working with these dairymen for many years. The results for samples entered by the dairymen follow:

SCORE OF HIGHLAND PARK MILK CONTEST (DEC., 1916).

Classified as:	Score.	Number of samples.	Per cent total.
Excellent	90–100	10	32.3
Very good	75– 90	17	54.8
Good	60– 75	2	6.4
Fair	50– 60	1	3.2
Poor	0– 50	1	3.2

Average score 85.02.

"In connection with this contest for the dairy farmers another class was provided. This included samples from each dealer selling milk in Highland Park. The samples were taken from the wagons of the dealers without any previous notice and represent the condition of the milk as delivered. With the exception of the bacterial count all determinations were made upon samples of milk taken from one delivery. The bacterial count is the dealer's average for the summer as run by the Bacteriologist of the Highland Park Board of Health. This is all pasteurized milk.

The results for samples taken from dealers' wagons follow:

SCORE OF HIGHLAND PARK MILK CONTEST (DEC., 1916)—CITY MILK DEALERS WAGON SAMPLES (PASTEURIZED).

Classified as:	Score.	Number of samples.	Per cent total.
Excellent	90–100	1	11
Very good	75– 90	8	89
Good	60– 75	0	0
Fair	50– 60	0	0
Poor	0– 50	0	0

Average score 81.7.

"At the request of the Grand Rapids Board of Health a milk and cream contest was judged at that place early in March. It is gratifying to see the high scores that were made in this contest. Grand Rapids was one of the first cities in the United States to have a milk contest and has had an annual milk and cream contest since.

"In this contest there were four classes as follows: Dealer Milk, Dealer Cream, Producer Milk and Producer Cream. These samples may be classified as follows in regard to score:

SCORE GRAND RAPIDS MILK CONTEST MARCH 2, 1917.

DEALERS CLASS—MILK.

Classified as:	Score.	Number of samples.	Per cent total.
Excellent	90–100	8	57.0
Very good	75– 90	5	35.8
Good	60– 75	1	7.2
Fair	50– 60	0	0
Poor	0– 50	0	0

Average score 84.7.

DEALERS CLASS—CREAM.

Classified as:	Score.	Number of samples.	Per cent total.
Excellent	90–100	4	100
Very good	75– 90	0	0
Good	60– 75	0	0
Fair	60– 60	0	0
Poor	0– 50	0	0

Average score 95.3.

PRODUCERS CLASS—MILK.

Classified as:	Score.	Number of samples.	Per cent total.
Excellent	90–100	8	57.1
Very good	75– 90	6	43
Good	60– 75	0	0
Fair	50– 60	0	0
Poor	0– 50	0	0

Average score 85.3.

PRODUCERS CLASS—CREAM.

Classified as:	Score.	Number of samples.	Per cent total.
Excellent	90–100	5	100
Very good	75– 90	0	0
Good	60– 75	0	0
Fair	50– 60	0	0
Poor	0– 50	0	0

Average score 94.7.

"A Milk Contest was judged for the Flint Board of Health in March. This was their fourth annual contest. The samples entered may be classified as follows:

SCORE OF FLINT, MICHIGAN, MILK CONTEST MARCH, 1917.

Classified as:	Score.	Number of samples.	Per cent total.
Excellent	90–100	14	27.5
Very good	75– 90	26	50.9
Good	60– 75	5	9.8
Fair	50– 60	5	9.8
Poor	0– 50	1	2.0

Average score 80.6.

"A comparison of the scores for milk the first time entered and the second time entered shows the following gratifying results: In the 1916 Grand Rapids Contest the fifteen producers who also entered the 1917 contest had an average score of 84.0. These same producers had an average score of 91.9 in the 1917 contest. In the 1915 State Fair contest were four who entered the 1916 Highland Park contest. These four had an average score of 89.0 in the 1915 contest and of 91.0 in the 1916 contest.

"Nineteen dairymen are found who entered two of the Flint contests. These nineteen had an average score of 80.8 the first time entered and 83.3 the second trial. These results, it seems to the writer, show that the milk and cream contests are a factor in improving the milk supply in that they teach the producer how best to handle milk that it may reach the market in the best possible condition. The fact that in the second contest, in each city where more than one contest has been held, the producer entered samples of milk which were greatly improved in quality it seems would justify the continuance of these contests on a greater scale." (L. H. Cooledge.)

I believe that the value of the milk and cream contests is sufficiently well demonstrated to warrant pushing this work with vigor. The production of better milk, purer milk and safer milk has not only its hygienic significance but its economic aspects. The condemnation of milk as unfit for human food or for direct consumption and the lessened use of milk as a result of the public attitude of distrust of milk supplies is disastrous to dairy farming. Only by determining the criteria of safe milk and by determining the most economical means of satisfying such criteria can the market milk business be established on a sound basis. This applies, but with less force, to dairy manufacture. I trust that Mr. Cooledge will find it possible to continue this work with vigor.

Mr. C. W. Brown reports on his work as follows:

"This year my attention has been centered upon: First, "Keeping Qualities of Butter"; second, "Lactic Acid Bacteria and Their Uses"; and third, "Food Fermentations." In addition allied subjects, some of which are herein briefly mentioned, received attention.

NEUTRALIZED CREAM FOR BUTTER-MAKING.

A vat of sour gathered cream was divided into two parts, one of which was neutralized with lime, and each part pasteurized in a vat pasteurizer at 145°F. for twenty minutes then cooled and chilled. The two divisions, after receiving an addition of about ten percent starter each, were churned at the same time in separate churns. Samples (3℔.) taken from the churns just before salting and others just after salting were placed in paraffined paper containers and set in storage at 32°F.

The data obtained from the products of this vat of cream are tabulated below.

The unsalted samples at the end of storage showed high acid a large part of which was soluble in water. Also the nitrogen in the form of proteoses and peptones was found to be much higher in the unsalted than in the salted. While these data are so few that conclusions cannot be drawn they indicate that butter from neutralized cream although not showing uniformly greater changes is less desirable for storage.

DATA FROM A CHURNING OF SOUR CREAM AND OF NEUTRALIZED CREAM

Determinations.	Sour Cream.		Neutralized Cream.	
	Salted.	Unsalted.	Salted.	Unsalted.
Fat content of cream	28.		28.	
Acidity of cream	0.54%		0.33%	
Moisture in butter	13.6	14	15.3	14.5
Score (2 days)	89	...	90	...
Stored at 32° F. for	315 days	315 days	315 days	315 days
Germ count after storage:				
Litmus lactose agar	970,000	50,000,000	1,000,000	115,000,000
Acid agar*	350,000	300,000	5,000	250,000
Organisms not enumerated	few molds	many molds	few molds	many molds
Score after storage	84	81	82	81
Salt	2.1	...	1.7	...
Moisture	15	12.5	14	11
Acidity of butter	0.20%	1.90%	0.70%	1.60%
Removed by washing	0.025%	1.03%	0.035%	0.75%
Nitrogen per 100 grms. butter... In proteoses and peptones	lost	0.0231	0.0098	0.0207
	lost	lost	0.0094	lost
In amino-acids and NH_3	lost	0.0079	0.0077	0.0081
	lost	0.0084	0.0080	0.0083

*This agar is selective for torulae.

EXAMINATION OF CHEESE.

1. There was examined a sample of cheese containing in every small opening (mechanical, at time of pressing or formed later by gas) small masses of white material which upon examination was found to be, not a bacterial growth, but rather a crystalline substance. They proved to be crystals of a nitrogenous compound, presumably tyrosin, a product of cheese ripening which under this particular environment crystallized.

2. Red ink-like spots on the rind and extending a short distance into a cheese were found to be the result of the growth of a red pigment forming bacillus (B. rudensis.)

VINEGAR SAMPLES.

Samples of vinegar sent in from various parts of the state by farmers, principally, who have had trouble in the making of vinegar were examined and the accompanying incomplete list is offered to indicate the nature of the samples. Some of these samples represent a barrel or a number of barrels of vinegar in the making, the age of which was given as from a few months to two or more years. They comprise under-strength vinegar with the alcohol nearly or completely converted thus leaving a product impossible of further development of acid, and hard ciders which under their environment refused to change into vinegar. The three chief causes of trouble are: First, diseases, i e., the growth of a group of bacteria in the must, favored by the use of unsound fruit, by

ANALYSES OF VINEGAR.

Sample No.	Acid (as acetic) per cent.	Alcohol (by Wt.) per cent.	Color.	Bouquet.	Remarks.	Suggestions.
1	3.50	3.80	Good	Good	....	Admit air and ferment.
2	1.40	3.84	Light	Good	Low in acid + alcohol	Admit air and ferment.
3	1.98	3.70	Light	Good	....	Admit air and ferment.
4	1.92	3.25	Light	Good	Low in acid + alcohol	Admit air and ferment.
5	0.80	3.82	Light	Poor	Turbit (bacterial disease) can not be made into vinegar with regulation strength.	Pasteurize at 150° F., mix with strong hard cider and ferment.
6	2.00	3.69	Good	Undeveloped	Slightly turbid	Admit air and ferment.
7	1.60	2.61	Good	Undeveloped	Low in acid + alcohol	Mix with strong hard cider, admit air and ferment.
8	1.10	3.90	Good	Undeveloped	Low in acid + alcohol	Admit air and ferment
9	1.00	4.15	Light	Undeveloped	Low in acid + alcohol	Admit air and ferment.
10	3.50	0.00	Good	Fair	Can not be made into vinegar with regulation strength.	Mix with strong hard cider and ferment.
11	1.20	3.50	Good	Foreign	Low in acid + alcohol	Admit air and ferment.
12	4.30	Present	Good	Good	....	Nothing required.
13	4.90	Present	Good	Good	....	Nothing required.
14	2.60	4.05	Good	Fair	....	Admit air and ferment.
15	0.90	6.40	Light	Fair	....	Inoculate, admit air and ferment.
16	4.70	Present	Good	Sharp	....	Nothing required.
17	3.70	....	Good	Fair	Sample too small	(?)
18	2.60	1.65	Good	Fair	Low in acid + alcohol	Mix with strong hard cider and ferment.
19	3.69	1.43	Good	Fair	Low in acid + alcohol	Admit air and ferment.
20	1.25	4.52	Light	Good	....	Admit air and ferment.
21	1.80	1.10	Light	Unpleasant	Cloudy (diseased)	No remedy to suggest.
22	2.10	0.25	Light	Fair	Turbid (diseased)	No remedy to suggest.
23	4.10	2.11	Good	Good	....	Ferment a little farther.
24	1.00	5.37	Good	Foreign	....	Inoculate, admit air and ferment.
25	0.70	5.05	Good	Good	....	Inoculate, admit air and ferment.
26	0.50	5.37	Light	Good	....	Inoculate, admit air and ferment.
27	0.50	5.86	Light	Good	....	Inoculate, admit air and ferment.
28	2.70	3.88	Light	Good	....	Inoculate, admit air and ferment.

extreme low acidity in the must and by a tardy alcoholic fermentation; second, the presence in the must of high acidity which retards, hinders, or prevents the work of the yeast in transforming the sugar of the juice into alcohol due to placing the fresh juice in casks containing a quantity of vinegar and to the growth of the acetic bacteria before the yeast has begun active work; and third, restraint of the supply of free oxygen (air) thus inhibiting the work of the vinegar bacteria in oxidizing the alcoholic liquid (hard cider) into vinegar due to the casks being full or nearly full and to closing or nearly closing the opening (bung); also trying to make vinegar at too low temperatures and disturbing the cask during the acetic fermentation should be included as causes of trouble.

Samples of different foods sent in for information relative to quality and for suggestions to prevent abnormalities have been examined and such information as was at hand and as was obtained, considering general conditions, was communicated to the inquirer.

From our collection of strains of miscellaneous microorganisms 79 have been prepared and sent gratuitously in response to requests from various educational institutions. In addition to these 7 lactic and 2 bulgarian cultures were dispensed for dairy and therapeutic purposes in the state; likewise 10 alcohol-acetic cultures for vinegar inoculation. (Chas. W. Brown).

Mr. Morgan reports as follows:

"The study of the soil solution was continued throughout the year. The publication of the work concerning the method of obtaining the soil solution has been held up for a year for the lack of funds. This will appear as Technical Bulletin No. 28, under the title of "The Soil Solution Obtained by the Oil Pressure Method." This describes the method of procedure together with some of the results of the study of these solutions. The manuscript of an abstract of the above bulletin has been accepted and will appear in the June number of Soil Science.

"The manuscript describing the results of the microbial action on nitrogenous substances in the soil as obtained by means of the study of the soil solution is now ready to submit to the council for consideration as a Technical bulletin. This bulletin is to consist of two parts. The second part is on work done in cooperation with Dr. R. P. Hibbard, Research Associate in Plant Physiology, on "Physiological Balance in the Soil Solution." Dr. Hibbard is the author of this part.

"The writer hopes to be able in the near future to present for publication in some scientific journal the preliminary work done in cooperation with Mr. W. S. Robbins, formerly of this department, on the growth of the hog cholera virus in the soil solutions. Some of the results were gratifying, but more work is necessary to make it conclusive.

"During the Christmas holidays I attended the annual meeting of the Society of American Bacteriologists held under the auspices of Yale University, New Haven, Connecticut." (J. Frank Morgan).

Mr. Morgan will continue his investigations, making use of the soil solution method in an effort to determine the factors, undoubtedly microbial, responsible for the conversion of the unavailable matter of peat and muck into matter available for agriculture. It is planned to cooperate with the muck crop specialist, Mr. Ezra Levin, of the Botanial Department.

Adams project 3a, Swine Epidemics, has continued to suffer as a result of our inability to retain the services of men employed to carry on

this project. Mr. L. C. Ludlum resigned at the close of the year (August 31, 1916), too late for us to fill his place satisfactorily. H. J. Stafseth, graduate assistant, was put in charge of the work and it has been possible for us to so estimate his ability and determine his qualifications that we felt safe in recommending him for this position. Dr. Stafseth will pursue the studies with special reference to hog cholera during the coming year. During the past year he has made preparatory studies which will enable him to enter upon his duties without delay. He has made a great many investigations for the State Live Stock Sanitary Commission and for others in the State. A considerable number of cases of avian tuberculosis has been determined.

Mr. Huddleson submits the following report of the work that he has directed and accomplished during the past year:

"My time has been devoted largely to investigations in bovine infectious abortion. Other work will be reported as miscellaneous. The completion of the experimental barn at the beginning of the year has greatly facilitated the investigation in this problem. There are now housed in the barn thirteen animals, including bulls and calves. Each animal has been used in the different problems throughout the year. I hope that we may be in a position to add at least twenty more heifers to our herd this year in order to carry out the problem of immunization on a more extensive scale.

"The Study of the Transmission of *Bact. abortus* to New Born Calves Through the Ingestion of Milk" was taken up during the year 1915 under the direction of Mr. L. H. Cooledge. A preliminary report (A Study of the Milk in Bovine Infectious Abortion, by Ward Giltner, L. H. Cooledge and I. F. Huddleson) was read (by W. G.) at the Annual Meeting of the American Veterinary Medical Association, Detroit, August 22, 1916. The investigation has since been continued, and a paper embodying the results and entitled, 'The Transmission of *Bact. abortus* (Bang) Through the Ingestion of Milk' was read by the writer at the Annual Meeting of the Michigan Academy of Science, March 29, 1917. The work will appear elsewhere in this report as Technical Bulletin No. 32.

"A technical article entitled 'The Specific and Non-Specific Action of Rabbit Blood Serum in the Complement Fixation Test' was published in the Journal of Immunology, Vol. 2, No. 2, February, 1917. A summary of the article follows:

"Rabbits do not develop antibodies in their blood for *Bact. abortus* when fed continually upon naturally infected milk (milk reacting to the agglutination and complement fixation tests for *Bact. abortus*).

"The blood sera of normal rabbits possess the property of fixing complement non-specifically in the presence of *Bact. abortus* antigen. This property is not explainable at this time.

"The problems which were outlined and to which considerable study has been given during the year are as follows:

1. The immunization of cows and heifers against infectious abortion.
    (a) The same applied to guinea pigs.

2. The length of time *Bact. abortus* survives when introduced into:
    (a) The uterus of cows.
    (b) The vagina of cows.
    (c) The sheath of bulls.

3. A comparative study of different strains of *Bact. abortus.*
   (a) Morphology and staining.
   (b) Cultural characteristics.
   (c) Antigenic and pathogenic properties.

4. The longevity of *Bact. abortus.*
   (a) On wool, linen and silk cloth.
   (b) In soil.
   (c) In sand and soil solution.
   (d) On hay (alfalfa and straw).

5. The value of different media for isolating and growing *Bact. abortus.*

"Immunization experiments: About one hundred heifers and cows have been given subcutaneous injections of killed and live suspensions of *Bact. abortus.* The first injection consisted of 10 c. c. of a dense suspension of the killed organisms. The second injection given ten days after the first, consisted of 20 c. c. of a dense suspension of the live organisms. Single injections of the killed and of the live organisms were also administered to a number of animals. The blood reactions of the animals were determined before and periodically after receiving the injections. Temperatures were taken and recorded after each injection. The results of the immunization will not be available until a later date.

"An immunization experiment using guinea pigs was attempted in the following manner: Ten virgin female guinea pigs were selected for the experiment. The blood of each pig was tested for *Bact. abortus* antibodies by means of the agglutination and complement fixation tests before the injections were given. Each of the pigs gave a negative reaction. Three succeeding subcutaneous injections consisting of a suspension of 10,000,000, of 100,000,000 and of 1,000,000,000 killed organisms were given at intervals of about ten days. Ten days following the third injection, one c. c. of a dense suspension of live organisms, was given to each pig in the same manner.

"Six of the pigs died before the experiment was finished. Of the remaining four pigs, one aborted two months after the last injection of organisms and the remaining three, on autopsy, showed *Bact. abortus* lesions in the liver and spleen. *Bact. abortus* was isolated from these organs. It is evident from the results that guinea pigs are not protected from infectious abortion, nor is the formation of lesions in the spleen and liver prevented by subcutaneous injections of a killed suspension of organisms.

"Two problems have suggested themselves as a result of researches in immunization:

(1) The complement fixation and agglutination tests as a means of differentiating between an infection and an immunity. The researches in this problem should not be reported at this time.

(2) The transmission of antibodies (agglutinating and complement binding) from mother to fetus in utero. The researches in this problem have been completed and will appear as a technical article in the October, 1917, number of the Cornell Veterinarian.

TABLE I.

Blood reaction.	Calf No. 1. (a)									Calf No. 2. (b)								
	Aggl					Comp. Fix.				Aggl.					Comp. Fix.			
	.1	.25	.03	.01	.005	.1	.04	.02	.005	.1	.25	.05	.01	.005	.1	.04	.02	.005
Before injection.........	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1st day after injection....	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3rd day after injection....	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
6th day after injection....	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
8th day after injection....	–	–	–	–	–	–	–	–	–	+	+	+	P	–	+	+	+	P
12th day after injection...	–	–	–	–	–	–	–	–	–	+	+	+	–	–	+	+	+	+
15th day after injection...	–	–	–	–	–	+	–	–	–	+	+	+	P	–	+	+	+	+
22nd day after injection..	P	–	–	–	–	+	P	–	–	+	+	+	–	–	+	+	P	–

(a) 5 c. c. of a dense suspension of *Bact. abortus* injected subcutaneously.
(b) 10 c. c. of a dense suspension of *Bact. abortus* injected subcutaneously.

"In order to throw more light upon the time of the appearance of antibodies after an infection or immunization, two calves were injected with suspensions of live *Bact. abortus* organisms. The time of the appearance of the antibodies was then noted. The results are summarized in Table I.

"It is evident from the data in Table I that the time of the appearance of antibodies depends upon the amount of material injected. One must take into consideration that the amount of material injected into the animals in this experiment is many times larger than that which would enter the body when exposed naturally to infectious material. Therefore, one would expect the antibody formation to take place more slowly as the result of natural infection.

"Experiments to determine the length of time *Bact. abortus* survived when introduced into the vagina of cows and the sheath of bulls are described as follows:

"Five cubic centimeters of a suspension of live *Bact. abortus* were placed in a gelatin capsule and introduced far up into the vagina of three cows. Swabs were made from the vagina twenty-four, forty-eight and seventy-two hours after introducing the material. The swabs were plated out immediately after being made. *Bact. abortus* was not in a single instance isolated from the vaginas treated in the above manner.

"Similar experiments with two bulls were carried out by gravitating twenty cubic centimeters of a live suspension of *Bact. abortus* into the sheath. Swabs were made and plated out in the above described manner. *Bact. abortus* was never isolated from the sheath.

"These experiments serve to demonstrate that, under normal conditions, *Bact. abortus* will not establish itself in the vagina of cows or the sheath of bulls.

"A comparative study of different strains of *Bact. abortus* was made.

"Morphology and staining characteristics: Apparently no difference.

"Pathogenic characteristics: Apparently no difference.

"Pathogenic and antigenic properties: The present data concerning this study reveal some very interesting facts. The results, however, have not been completed owing to the death of so many of the experimental guinea pigs. The results will be published at a later date.

"Longevity studies of *Bact. abortus:* Into suspensions of eleven different strains of *Bact. abortus* in sterile physiological salt solution were placed small pieces of sterile wool, linen and silk cloth. The pieces of cloth were removed from the suspension of bacteria after they had become uniformly saturated and placed in sterile petri dishes. The dishes were kept in a well lighted room without direct sunlight. From day to day, pieces of each different kind of cloth were removed from the dishes and smeared on agar plates. The appearance of colonies was noted under aerobic and anaerobic conditions. None of the eleven strains of *Bact. abortus* was isolated from the wool or from the silk cloth after two weeks. Two of the strains were able to survive on linen cloth for four weeks.

"The experiments with sterile soil, sand plus soil solution, hay and tap water were conducted in a manner similar to the above. The materials were placed in sterile flasks, and to each was added one cubic centimeter of a suspension of *Bact. abortus* in sterile physiological salt solution. Each of the flasks of material was shaken from day to day and plated out to determine the presence of *Bact. abortus.* The follow-

ing results were obtained: *Bact. abortus* could not be isolated from soil after one week and from sand plus soil solution after less than seven days. The hay became contaminated and the experiment was discontinued. The bacteria survived in tap water for nineteen days.

"Since other bacteria which may have grown in symbosis, antibiosis or metabiosis with *Bact. abortus* were not taken into consideration in these experiments, only tentative practical conclusions can be formed from the results. The importance of the results, however, is apparent when one takes into consideration the above materials as a means of conveying the causative organism of abortion from animal to animal and from one herd to another and the disaster that may result therefrom.

"The following combinations were employed in an effort to arrive at a medium upon which *Bact. abortus* would grow more luxuriantly and with greater speed:

Blood Clot agar (blood clot one volume, water two volumes),
Ascitic agar (ascitic fluid taken from fetus),
Amniotic agar (fluid taken from amnion).
Fetal agar (aborted fetus ground and made up as meat infusion),
Glycerin agar and plain agar varying in different degrees of acidity.

Results: *Bact. abortus* grew well on all media excepting glycerin agar. and plain agar made neutral or 1.5 acid (Fuller's Scale) to phenolphthalein. Plain meat infusion agar or blood clot agar made 1.2 acid to phenolphthalein are much more to be preferred for the growing of *Bact. abortus* owing to the fact that the organism can be isolated on these media without difficulty when anaerobic conditions are employed (Nowak). One should never attempt to isolate *Bact. abortus* without employing the anaerobic method. The writer has found that it is absolutely impossible to isolate the organism under aerobic conditions.

"Nine aborted fetuses and one still born were examined bacteriologically during the past year. *Bact. abortus* was isolated from the stomach contents of eight. The organism was not isolated from the still born or from one of the aborted fetuses. In only one instance was the organism isolated from the fetal blood, spleen, kidney and liver, as well as from the stomach content. *Bact. abortus* apparently establishes itself in the fetal stomach, and cannot be easily found in the other fetal organs.

"During the past year 343 blood samples have been tested by the complement fixation and agglutination tests for infectious abortion of which 136, or 39 percent gave positive reactions. These results give one a fair representation of the extent of the infection in the state of Michigan.

"At the beginning of the year an abortion record sheet was designed for the collection of data concerning sterility, retained placenta and the number of aborters that give positive reactions. Forty-six of the record sheets were sent to different veterinarians and breeders who had sent as blood samples to be tested for infectious abortion. Only 28 of the sheets were returned.

"The blood of 9 bulls, all located in badly infected herds, was tested during the year. There were 2 reactions obtained by the complement fixation test.

"Experiments are being conducted at the present writing to find a

chemical specific for *Bact. abortus* in vitro and in vivo. Formaldehyde, mercuric iodide and Dakin's solution are giving very promising results. The work should not be reported at this time.

"A study of the bacterial flora of the generative organs of the cow was taken up by Mr. W. C. Keck at the beginning of the year and later completed by Mr. Bolton and the writer. (This is a problem that this laboratory has had under consideration for about eight years. W. G.) The results are as follows: Swabs for the determination of the bacterical flora were made from 30 cows. Of the 30 cows, swabs were made from the vaginas of 30, from the uteri of 23. Thirty-four different organisms were isolated from the vaginas and 24 from the uteri. There were 52 different organisms isolated, 5 of which occurred in both uterus and vagina. There were no two cows which showed an identical flora in either the uterus or the vagina. There was very little similarity in the bacterial flora of any two cows. Swabs were made from the sheath of several bulls and of the organisms isolated (20 in number) only one organism was found to occur in the sheath of bulls that did not occur in the uterus and vagina of cows.

"Organisms were found as follows: Bacterium 22, Bacillus 3, Micrococus 11, Streptococcus 4. Apparently the predominating organisms belong to the genus Bacterium. The media used for isolating the organisms were plain agar (1.2 acid to phelolphthalein) and neutral plain agar. In the course of the work it was found that many of the organisms would appear only on neutral media. As the body fluids are slightly alkaline there is every reason to believe that many of the bacteria existing under such condition would require an artificial medium having a similar reaction.

"Mr. Manuel Justo, graduate student in this department, has completed a comparative study between the bacterial flora of the udder and that of the genital organs of the cow. His brief conclusions are as follows: First: The normal bacterial flora of the udder is comprised of microorganisms which belong to two types, the micrococci and the staphylococci, varying in pigment production, fermentation reactions, hemolytic power, and the other tests to which they have been subjected. Second: Of the twenty-five different samples of milk studied, these two types have been considered as representing the bacterial flora of the normal udder. This does not preclude the possibility that, had a larger number of samples been studied and more colonies subjected to examination, other types might have been isolated.

Third: The comparative study between the organisms isolated from the udder and those isolated from the genital organs reveals no close similarity between the bacterial flora of these two sources.

HEMORRHAGIC SEPTICEMIA.

"Hemorrhagic septicemia of the bovine has become a very important problem in Michigan during the past year. In fact, the number of reported outbreaks that come to our attention seems to be on the increase from year to year. Laboratory diagnosis of this disease has been confirmed by animal inoculation from infected tissue for Dr. Dunphy, State Veterinarian, on the following dates: October 31st, November 5th, November 8th, November 10th, November 21st, December 13th, 1916 and on March 3rd, March 20th, April 4th, and April 25th, 1917.

"An attempt is being made to employ the agglutination and comple-

ment fixation tests in the diagnosis of hemorrhagic septicemia. Encouraging results have been obtained with the complement fixation tests. The greatest trouble lies in the delayed non-specific reaction caused by normal serum. An attempt is being made to overcome this difficulty at the present writing. The agglutination test has given only negative results.

"The following trips have been taken during the year:

October 5th and 27th, accompanied Dr. E. T. Hallman to Howell to treat herd for sterility.

April 1st, visited dairy farm near Coldwater to outline treatment for abortion and apply abortion vaccine treatment.

June 15th-16th, collected abortion material from Parker and Webb packinghouse at Detroit.

CASE REPORTS.

"Sterility: This cow gave birth to her first normal heifer calf May 28, 1916. About six weeks after calving she was noticed to be in œstrum and was served by the herd bull on the same day. She was noticed to be in oestrum on the following day and for several days succeeding. The ovaries were palpated through the rectum and each found to contain a large cyst. The cysts were removed by pressure. The cow was placed on pasture during the summer and was not observed until September. The ovaries were again palpated, found to be cystic and the cysts were removed. This procedure was carried out about once every month. Oestrum occurred weekly. On March 22, 1917, ovariotomy was performed and the right ovary was removed. The ovary contained two cysts about one inch in diameter. The cystic fluid was examined bacteriologically for organisms, with negative results. On April 30th, the cow was slaughtered. The uterus was normal in size and contained very little mucous exudate. The remaining left ovary contained a cyst about 1.5 inches in diameter. A bacteriological examination of the cystic fluid revealed no organisms. The same was made of the uterus, pelvic lymph glands and udder. A few micrococci and staphylococci were found in the uterus and lymph glands and micrococci and *Bact. abortus* from the udder tissue. Only two colonies of *Bact. abortus* were found on the entire number (25) of plates made from the udder tissue.

"Granular Vaginitis: This herd of dairy cows came to our attention through Dr. McKercher and Dr. Keck of Lansing. The owner reported that he was having considerable trouble to get his cows to conceive. He had had no abortion in his herd. On examination of the animals, it was found that nearly every cow, including the calves, were affected with granular vaginitis. Nine cows were selected indiscriminately throughout the herd and the blood tested by means of the agglutination and complement fixation tests for infectious abortion. Not one of the samples tested gave a positive reaction.

"Acute Interstitial Nepritis of the Equine: A report concerning a number of interesting cases of this disease in suckling colts has been accepted for publication by the Journal of the American Veterinary Medical Association, under joint authorship of Dr. E. T. Hallman and the writer." (I. F. Huddleson).

The abortion problem is one of the big problems confronting Michigan agriculture, perhaps the biggest menace to animal industry. Mr. Hud-

dleson is attacking it with energy and intelligence. More funds should be available for additional men and equipment.

Miss Northrup, Assistant Bacteriologist, submits the following report on bacteriological water analyses from July 1, 1916, to June 30, 1917:

"During the past fiscal year forty-five samples of water were analyzed. All except five of these were from wells from rural communities. Fifteen of the latter, 37.5%, showed a bacterial count of less than 100 per cubic centimeter of water, and two of these thirteen contained no organisms which would grow on litmus lactose agar at 37°C. An important fact however is to be noted,—*five of the fifteen samples showing this low bacterial count were more or less polluted with intestinal organisms of the colon type.* This shows that the bacterial count alone cannot be depended upon to indicate the purity of water. Water of this type is most dangerous as it is deceiving to the consumer and also to the analyst unless he uses a considerable number of tests some one or two of which will give positive results.

"Eleven samples contained between 100 and 1,000 bacteria per c. c. five of these showed sewage contamination. The remaining nineteen contained from 1,000 to 8,000 bacteria per c. c. with four exceptions the counts of which ran over 16,000, 22,000, 43,000 and 83,000 per c. c.

"These analyses perhaps in some cases are not in any way indicative of the sanitary condition of the water just as it was drawn; there are so many factors that may enter into this problem and complicate matters or change them entirely before the analyst gets the sample. Some of these are the container, the stopper or cover of the container, the technic of obtaining the sample, the method of shipping and the time on the road, all of which are in a large measure beyond the analyst's control. For example, water samples are frequently sent in lemon or vanilla extract bottles, liniment bottles, etc., with the original cork which may contain enough of certain essential oils or other compounds to have a decided antiseptic effect on the organisms present. Other bottles may contain small amounts of substances which will serve as a food and thus cause the bacteria to multiply enormously. Handling sterile containers may be done in such a way as to contaminate them with organisms of the sewage type. An instance of this occurred this year. Two samples were sent in for analysis from a large farm near Grand Rapids both of which proved to be contaminated. A letter to this effect produced great surprise to the sender and when the conditions surrounding the wells were noted they seemed ideal. The suggestion was then made to him that this contamination resulted from improper handling of the containers. A second sample analyzed after the suggestion was made use of proved the point.

"It seems as if the people of Michigan should be made acquainted through this college, not only with the proper way to obtain and ship water samples for bacteriological analysis, but with the proper methods of well construction and of sewage disposal which are of equal importance in determining the health of the rural population.

"One water sample from a deep spring was sent in for determination of green material present. On microscopical examination this proved to be due to a microscopic form of plant life called *Protococcus*. Another which was sent in for determination of cause of a brown scum proved to be affected by the growth of iron bacteria.

"A bottle containing a 10% solution of Rochelle salt, potassium and sodium tartrate, was sent in to determine the cause of the brownish-black growths found in it. Cultural methods and microscopical examination showed the presence of two molds, a Penicillium and an unidentified pink mold. (Zae Northrup).

Miss Northrup also submits an initial report on bacteriological canning problems for year 1916-1917:

"This past year studies have been made on spoiled canned goods both domestically and commercially prepared. The few samples of home canned goods analyzed were miscellaneous vegetables and fruits canned by the cold-pack method in glass 'self-sealer' cans. Most of the canned foods examined were commercial goods (canned in tin) and the 'spoiled' cans analyzed have been either 'swells' or 'springers.' On account of the difficulty in obtaining samples of spoiled home-canned foods for investigation arrangements were made with the wholesale grocers in Lansing to furnish our laboratory with any spoiled cans which they happened to have. In this way we have obtained quite a number of samples of different vegetables and fruits for analysis.

"Analyses are made to determine the number of aerobic and anaerobic microorganisms per cubic centimeter in the liquid, the gases quantitatively and qualitatively and the reaction of the liquid. Direct microscopical examination is made of the liquid to determine the presence of microorganisms. When found by cultural methods, they are isolated and studies necessary for their identification are made; their resistance to heat and to acids is also determined, in fact every effort is made to see whether these organisms have anything to do with the particular type of spoilage in the food from which they are isolated.

"Many cans have proved to be sterile. This may not be a correct statement, however, as the methods employed for analyses with these particular cans may not have been the right ones. This is one of the difficulties to be overcome.

"Bacteria have been isolated from spoiled cans of commercially prepared fruits and vegetables. In some cases it has been possible to reproduce spoilage, i. e. 'swells' by inoculating a sterile can of a fruit or vegetable with the organism obtained from a spoiled can of the same fruit or vegetable. Enough work has been done already to show us many faults in the methods, consequently at present we are attempting to perfect our apparatus and technic. Mr. Leroy W. Mallman, Miss Elsa Schueren and Mr. Glen I. Blades have contributed largely to the production of the data obtained.

"A completely equipped canning kitchen has been installed in the basement of our laboratory and in cooperation with Mr. Lindemann and Miss Cowles, who are going to do experimental work in canning, we expect to learn at first hand some of the problems of the home canner with the advantage that data will be obtainable on every stage of the process." (Zae Northrup).

Mr. Charles G. Nobles submits the following report:

"The past year has been spent with two phases of work with nodule forming bacteria, the production and distribution of cultures and investigation or experimental work. During the spring from April 1st to July 1st my time has been given over almost entirely to the details of preparation of media, inoculation and disposal of the cultures.

FOLLOWING IS A REPORT OF CULTURES DISTRIBUTED BETWEEN JULY 1, 1916 AND JULY 1, 1917.

	*Alf.	S. C.	R. C.	Al. C.	W. C.	F. B.	S. B.	G. B.	F. P.	C. P.	V.	G. P.	S. P.	Total.
July	222	17	10	....	....	....	5	1	....	5	19	....	....	279
August	607	49	44	1	....	....	2	....	1	....	179	....	....	883
September	98	8	23	....	1	2	2	2	2	2	96	2	....	238
January to April	123	37	61	3	....	4	5	....	....	1	8	1	2	242
April	827	225	275	16	....	....	29	3	100	16	7	14	8	1,520
May	482	69	65	7	....	197	542	14	50	42	12	4	1	1,485
June	301	43	11	....	....	1,051	470	3	....	23	4	1	....	1,913
Total	2,560	448	489	27	1	1,260	1,055	23	153	89	325	22	11	6,563

*Alf., Alfalfa; S. C., Sweet Clover; R. C., Red Clover; Al. C., Alsike Clover; W. C., White Clover; F. B., Field Bean; S. B., Soy Bean; G. B., Garden Bean; F. P., Field Pea; C. P., Cow Pea; V., Vetch; G. P., Garden Pea; and S. P., Sweet Pea.

EXPERIMENTAL WORK.

"Two hundred isolations have been made of Ps. radicicola from alfalfa, clover, peas, beans, soy beans and vetch. These are to be used in making extensive inoculations to study variations of the various strains of the organisms. Before progress could be made with this study it was necessary to devise or secure a satisfactory method of determining the infecting power of the organisms. Nitrogen-free agar has been tried but unsatisfactory results have been common. Sterile sawdust has been used to cover the surface of the agar. This gives indications of preventing contamination and providing a desirable medium in which the seeds may germinate. This also retards evaporation from the agar. Another method was tried with promising results. Several pieces of gravel were placed in test tubes of about one inch diameter. These tubes were mounted on foot. Small capillary tubes were placed in each test tube for use in watering the plants from the bottom. Soils and sand were tried in these. It was found that a compost rich in organic matter gave better results than sand. Muck obtained from a cultivated field when used to grow legumes resulted in the formation of nodules on red clover, alfalfa, common beans, Canada peas, soy beans and winter vetch without artificial inoculation.

SUMMARY OF QUESTIONNAIRE.

"The information obtained by a questionnaire sent to each of the experiment stations in the United States is summarized in Table I. The points about which information of particular interest was secured are in order of the columns of the table as follows: (1) Whether the practice of inoculation is extensively practiced, (2) and (3) the legumes requiring and not needing inoculation, (4) whether inoculation is principally by soil or pure cultures, (5), (6) and (7) refer to the furnishing of cultures, (8) gives an estimate of the percentage of successful inoculations, (9) gives the answer as yes or no regarding the desirability of encouraging the practice of inoculation by pure culture, (10) gives opinions on the reliability of commercial cultures, (11) contains answers to the question, 'After once inoculating a field do you think subsequent inoculations necessary for the same legume grown in rotation with three years non-legumes or legumes requiring a different strain of Ps. radicicola?' (12) refers to extension work with inoculation and (13) gives the number of bulletins or circulars published by the station on the subject.

State.	1. Inoc. Exten. Prac.	2. Legumes requiring inoculation.	3. Legumes not requiring inoculation.	4. Principal methods. Soil.	Culture.	5. Culture furnished.	6. Medium used.	7. Number.
Alabama	+	C. C., V., Alf.	V., B., Alf., S. Clo	+	+			
Arizona		Inoculation not necessary.						
Arkansas	−	V. Clo's., Alf., S. B.						
California	−	Alf.		+				
Colorado	−			+				
Connecticut	−	Alf., S. B.	Clo's., C. P.	+				
Delaware	+	Alf., S. B.	Clo's.	+		Soil (1)		
Florida	−		V. B.		+			
Georgia	−	Alf., C. P., V.	S. B., C. P., V.		+			
Illinois	+	Alf., S. B., S. Clo., V., C. P.	C. P., Clo's.	Glue(2).		Soil (1).		
Indiana	+	Alf., S. B., V.	Clo's., C. P.	+				
Kansas		Only in eastern	part of state.					
Kentucky	+	Clo's., V., Alf., Swt. Clo., S. B.	Same under conditions.	+	+	+	Agar	2753 in 1916.
Maine	−	Alf	No common legume.		+ Alf.			
Maryland		Alf., S. B., V		+				
Massachusetts		New in any section.			+	+	Agar	
Minnesota		Alf.	Clo's.	+	+			
Missouri	+	All but Alf.	R. C., C. P.	+	+			
Montana	−	S. Clo.		+				
Nebraska	−	Alf., S. Clo.		+				
Nevada	−				+			
New Hampshire	1st time. +		Clo's.			Soil (1).		
New Jersey		Alf., S. B.	Clo's., P., B.	+	+			
New York	+ Alf.	Alf., S. B., V.	All others	+	+	+	Ashbys (3)	7291 in 1915.
North Carolina	+	Clo's., Alf.	Peas, beans		+	+	B. P. I. (4)	4000-5000 yearly.
North Dakota		Alf., S. Clo., R. C.	Depends on crops	+				
Ohio	+	Alf., S. B., when new crops.	Clo's.	+	+			
Oregon	+	Alf., Clo's.	Clo's.		+	+	B. P. I.	
Pennsylvania	+	Alf., S. B., V.	Clo's., Swt. Clo., S. B.			Soil (1)		
Rhode Island	+	Alf.	Clo's., P. beans.	+	+			
South Carolina								
South Dakota	+ Alf.	Alf.	Swt. Clo., peas, beans.					
Tennessee	+ Alf.	Alf.	Peanuts, C. peas, clover.	+				
Texas	−		C. peas, peanuts, alfalfa.		+			
Virginia	+	Alf., S. B., V.	C. P., Clover		+			
Vermont	+ Alf.	Alf.	Clo's., S. clover.	+				
Washington	+	All			+	+	B. P. I. (4)	For 765 acres.
West Virginia	+	S. B., C. P., Alf.	Clo's.	+	+			
Wisconsin	−			+	+			

TABLE I.

8. Estimate of per cent successful.	9. Should inoculation be encouraged	10. Commercial culture.		11. (*)	12. Is extension work done.	13. Bulletins.
....	+	....	+	....	....	3, 14, 87, 96, 105.
....	....	....	....	....	....	....
50	+	....	....	....	....	....
....	....	....	....	....	....	....
....	....	....	....	....	....	....
....	+	....	....	....	....	....
50	....	....	....	No....	....	B. 115.
....	....	....	....	....	....	....
....	+	....	....	No....	....	....
Very low....	−	....	+	Not for many years.	County agents....	B. 76, 94, 179. C. 86.
75	....	....	....	No....	....	C. 36.
....	+	....	....	No....	....	C. 44. B. 97.
High....	+	....	....	No....	County agents....	B. 184.
....	+	+	....	No....	....	....
....	....	....	....	No....	....	....
Soil more successful....	+	....	....	....	....	....
....		....	....	....	Demonstrations....	....
....	If soil not available	....	....	....	....	....
....	+	....	....	No....	....	....
....	+	....	....	No....	Field demonstrations.	....
....	+ Soil pref.	....	....	....	....	....
70	+	....	....	No....	....	....
....	....	....	....	....	....	....
....	New regions....	....	....	No....	....	....
....	+	....	....	Depends on seasons.	....	....
....	Probably....	....	....	....	County agents....	....
....	+ Soil pref.	....	....	No....	....	....
68-70	+ New regions.	....			....	....
....	....	....	....	No....	....	....
....	+	....	....	....	....	....
....	....	....	....	....	....	....
....	+	....	....	....	....	....
....	Soil Pref....	....	+	....	....	....
....	+ Soil Pref.	....	....	....	....	....
....	+	....	....	No....	....	....
....	+	....	....	....	....	....
80	....	....	....	No....	....	....
75-90	+	....	....	No....	....	....
....	Soil Pref....	+	+	....	....	....

*See reference to column (11) preceding Table I.
S. Clo. Sweet Clover.
S. B. Soy Beans.
V. Vetch.
R. C. Red Clover.
C. P. Cow Pea.
C. C. Crimson Clover.
(1) Soil from field sent out to farmers.
(2) Glue method of inoculation, Circular 86, Ill. Exp. Sta.
(3) Ashby's agar used to propogate organism. Cultures distributed in sand.
(4) Medium given in Bul. 71, p. 27, V. A. I.

"The table above reveals some interesting facts. It shows that, while the comparatively new practice of soil inoculation has been employed

very widely, yet no investigational work is recorded that would specify need of inoculation of any legume except alfalfa. Methods of seed and soil treatment have been devised but the field of their applicability has not been satisfactorily settled. A great part of the material on the subject is a matter of opinion as far as the application of the inoculation to practical farm conditions is concerned.

"Neither the legumes requiring nor those not requiring inoculation were definitely stated. Alfalfa is more commonly treated than any other. Every station that mentioned a need of inoculation for any crop included alfalfa. The extent of the use of the soil and pure culture methods of treatment was about equal. No station expressed a preference for pure culture while, as will be noted, several perfer soil. Illinois, however, is the only station that shows an attitude of antagonism to pure culture.

REVIEW OF REPORTS.

"The furnishing of pure cultures for legume inoculation was taken up somewhat as an experiment. To ascertain the results of seed inoculation report blanks have accompanied each culture sent and a request is made to return this properly filled out with data of the crop that show the influence of inoculation. Not only have the number of reports received been disappointing but also in many instances the information and answers they contain. The reports returned in 1914, 1915 and 1916 total 224 while during the same period, 24,444 cultures were sent out.

"The first detail considered in reviewing these reports is the farmer's estimate of whether their crop was benefited. The following table contains a summary of the answers to the question 'Was your crop benefited by the treatment?' It was thought advisable where some factor was definitely known to have interfered with the crop not to include the reports in column 1 and 2 but to class them as indifferent—column 3.

TABLE II.—SUMMARY OF INOCULATION REPORTS.

	1914.			1915.			1916.		
	*B.	N. B.	I.	B.	N. B.	I.	B.	N. B.	I.
Alf.	58	11	6	30	7	3	27	8	8
Clovers	7	1	1	7	2	....	2	....	....
Vetch	8	6	1	....	4	....	....	....	....
Soy Bean	2	....	1	5	....	....	....	....	....
Peas	....	1	....	....	....	....	....	....	....
Beans	1	1	2	1	3	....	1	1	1
Swt. Clo.	....	....	....	....	....	....	3	....	2
Swt. Peas	....	....	....	....	....	....	1	....	....

* B. Benefited, N. B. Not benefited, I. Indifferent.

"The reports on legumes other than alfalfa have been so few that they have little value in concluding as to the success of inoculation of these crops. Because of this the alfalfa reports are the only ones to be farther considered in noting the influence of various factors on inoculation. Many reports received did not indicate that sufficient precaution had been taken in carrying out the experiment to warrant the answer given to the question respecting benefit to crop. For instance, although there was no seed planted uninoculated, the answer would be that the crop

was benefited. While the decision of a farmer may have resulted from intelligent observation and study of his crops from year to year yet these data should hardly be considered seriously as evidence for or against inoculation.

"Table III is my estimate of the benefited, not benefited and indifferent. In this only alfalfa is considered. All reports that show evidence of the farmers not having followed suggestions for the comparison of treated and untreated are classed as indifferent.

TABLE III.

	Benefited.	Not benefited.	Indifferent.
1914	23	13	33
1915	18	8	12
1916	17	8	17

"Even by following this conservative arrangement of reports the number of instances of benefit is sufficiently high to emphasize the success of cultures for alfalfa. In 1916, of the eight instances where the crop was not benefited, four reported the lack of nodules on the inoculated plants as well as on the treated. In either case the poor results might, of course, be due to improper handling of the culture and the treated seed.

"Following the farmers' estimate of benefit to their crops a study was made of the reports to ascertain if possible the influence of the crop management upon the success of inoculation. The definiteness and consequent value of this review, being determined by the success of the crop instead of the success of inoculation, is questionable. Table IV is a review of the results of liming as compared to not liming. In the light of the general opinion concerning the necessity of liming, to not only assure nodule formation but also crop success, the figures are surprising if taken seriously.

TABLE IV.—INFLUENCE OF LIMING.

	Limed.			Not Limed.		
	Benefited.	Not benefited.	Indifferent.	Benefited.	Not benefited.	Indifferent.
1914	26	6	3	28	5	3
1915	12	2	2	5	2	0
1916	14	3	2	12	5	5

"Table V. VI and VII respectively are reviews of dates of seeding, soil types and nurse crop on the relative numbers of successes and failures. None of these contains sufficiently conclusive data to justify any decision.

TABLE V.—INFLUENCE OF DATE OF SEEDING.

	April.			May.			June.			July.			August.			September.		
	B.	N.B.	I.	B.	N.B.	I.	B.	N.B.	I.	B.	N.B.	I.	B.	N.B.	I.	B.	N.B.	I.
1914....	4	0	0	16	5	3	11	3	1	9	2	2	13	1	0	4	0	0
1915....	4	1	0	6	2	0	9	3	2	3	0	0	6	1	0	1	0	0
1916....	5	0	1	7	1	2	5	4	0	3	0	1	6	2	2	1	0	1

TABLE VI.—INFLUENCE OF SOIL TYPES.

	Gravel.			Sand Loam.			Sand.			Clay to Clay Loam.		
	B.	N. B.	I.	B.	N. B.	I.	B.	N. B.	I.	B.	N. B.	I.
1914.......	8	1	0	8	6	1	6	0	1	24	1	2
1915.......	4	0	0	10	1	1	3	0	1	12	5	......
1916.......	6	2	0	4	0	0	6	1	4	8	3	3

TABLE VII.—INFLUENCE OF NURSE CROP.

	Barley.			Oats.			Rye.			Wheat.			Corn.			No Nurse Crop.		
	B.	N.B.	I.	B.	N.B.	I.	B.	N.B.	I.	B.	N.B.	I.	B.	N.B.	I.	B.	N.B.	I.
1914....	0	1	0	10	2	2	0	2	0	0	1	0	0	0	0	31	6	3
1915....	2	0	0	2	1	0	0	0	0	0	0	0	0	0	0	15	3	2
1916....	4	0	1	4	0	1	2	0	1	1	0	0	0	0	1	15	7	2

Also Buckwheat 1, Indifferent.

"Indications are that a higher percent of success results from seedlings in April or early spring, late summer and early fall. These data undoubtedly apply more to alfalfa cultivation than to inoculation.

"Of the reports of 1914, ten either specifically mentioned a high organic matter content of the soil, implied it, or stated that manure had been applied to the field. Of these reports every one was affirmative regarding the success of inoculation, the most emphatic announcements of success being included among them.

GENERAL DISCUSSION.

"The value of all results must be minimized by the fact that no two men would have similiar standards for judging their results. Dependance on the public for a verdict on inoculation as indicated by these reviews is unsatisfactory and emphasizes the need of a field study of legumes and inoculation. Although cultures have been furnished for eight years yet we are in no position to say that Michigan legumes except alfalfa have been or can be materially benefited by inoculation. We

are suffering from a lack of knowledge of the natural distribution of the various strains of the nodule forming bacteria and because of the comparative ignorance of the effect of various factors upon infection and the subsequent influence of the infection by Ps. radicicola.

SUMMARY.

"1. Pure cultures for alfalfa, from the indication of the reports have been highly successful.

"2. No conclusion can be made regarding the value of inoculation of other legumes than alfalfa.

"3. No satisfactory conclusion can be derived regarding the influence of liming, date of seeding or nurse crop on inoculation.

"4. The presence of organic matter favors success with inoculation." (Charles G. Nobles).

"We have submitted to you for publication herein a great many reports on matters that can be recorded conveniently only through this channel and which would not be otherwise brought to public attention. I wish to commend highly the faithful and energetic services of all those who have contributed to this report, to assure you of their loyalty and devotion to the purposes of the Experiment Station and to convey to you for them and for myself an expression of our appreciation of your constant assistance and sympathetic counsel during the past year.

Respectfully,
WARD GILTNER,
Bacteriologist.

East Lansing, Mich., June 30, 1917.

REPORT OF THE BOTANIST.

Dean R. S. Shaw, College:

Dear Sir:—I hand you herewith my report as Botanist of the Experiment Station.

The botanical staff for the past year has consisted of myself, Dr. G. H. Coons, Research Associate in Plant Pathology, Dr. R. P. Hibbard, Research Associate in Plant Physiology, J. H. Muncie, Assistant in Plant Pathology, and, for part of the year, H. L. Lewis and R. Nelson, Quarter-time Graduate Assistants. R. W. Goss continued as an assistant in plant pathology on some potato disease work for part of the summer of 1916. In addition to these, considerable labor, chiefly of students, has been employed in the care of field plots, preparation of culture media, taking of routine records, etc.

My work had been the coordination of the botanical work of the College and Experiment Station, the general supervision of all the botanical work of other members of the staff and in particular the supervision of the cooperative cucumber disease work. I planned a small piece of work on rye smut which was carried out with the assistance of W. K. Makemson, a graduate student in Botany.

The cooperative work on cucumber diseases had been carried on through an arrangement between the H. J. Heinz Pickle Company of

Pittsburgh, Pa., the U. S. Department of Agriculture, and the Experiment Stations of Michigan, Indiana and Wisconsin. The Heinz Company established Heinz Industrial Fellowships at this institution and at Purdue University and the University of Wisconsin, paying the salary of one graduate student at each institution and his field expenses during the summer. These students were assigned different diseases of the cucumber for investigation, these being their major graduate subjects. Their summers are spent at field stations in their respective states where their whole time is devoted to their major problems from their practical aspects as well as from the laboratory standpoint. The Bureau of Plant Industry of the U. S. Department of Agriculture is represented by Mr. W. W. Gilbert, who has had general charge of the work and has attempted to so coordinate the investigations that there should be as little duplication of work as possible. One field man was also provided for each field station to do spraying, take records, etc. The fields and buildings for the field stations and the labor and fertilizers connected therewith were furnished by the Heinz Company. The laboratory equipment for the Michigan field station situated at Big Rapids, was loaned by the Botanical Division of this Station. I had charge of the work of the Industrial Fellow assigned to Michigan, planning and overseeing his work at the College and also at the field station. Mr. S. P. Doolittle began as our Industrial Fellow in May, 1914, on an agreement between the Heinz Pickle Company and this Experiment Station and College, a year before similar fellowships were established at Indiana and Wisconsin or the U. S. Department of Agriculture became a party to the agreement. He was stationed at Hamilton for that season, beginning work on the disease since known as Cucumber Mosaic, as well as on Cucumber Scab. He continued the work on these two diseases during the ensuing College year, receiving his M. S. degree in June, 1915, with a thesis entitled "Cucumber Scab caused by Cladosporium cucumerinum." This was published in the 1915 Report of the Michigan Academy of Science. The field laboratory in 1915 and 1916 was located at Big Rapids. These two summers and the intervening college year Mr. Doolittle devoted to an intensive study of the mosaic, which he demonstrated to be a communicable disease, carried by several kinds of insects, by the hands of the pickers, and by any means which would break the cells of a diseased plant so as to permit the escape of the juices and allow them to reach a similar break on a healthy plant. He also showed that squash, muskmelon and other members of the family were subject to the same disease and that it could be transmitted from one to the other by the means mentioned above. No causal organism could be demonstrated and the juices were found to be still infectious even after filtering through certain grades of porcelain (bacteriological) filters, demonstrating that the organism that causes the disease, if there be one, is extremely minute. The disease is one of a great class of little understood diseases of which the mosaic of tobacco has been given a great deal of study. Other diseases apparently closely related to it are peach yellows and little peach, mosaic of potato, of bean, of raspberry, etc. In the April, 1916, number of the periodical Phytopathology Mr. Doolittle published a short note upon the results of his cucumber mosaic work.

At the close of the summer of 1916 Mr. Doolittle decided to go to the University of Wisconsin to complete his work for the degree Ph. D. The fellowship at that institution having become vacant, the Heinz Com-

pany transferred him to that fellowship and discontinued the Michigan fellowship for the present.

In connection with this work I visited the experimental field and laboratory at Big Rapids twice last summer and attended a conference of representatives of parties to the agreement at Pittsburgh in January of this year.

I had hoped that conditions might be such that I might take up, with some assistance, the broader question of mosaic diseases in general, but under the present adverse financial conditions I have not been able to have funds assigned for this purpose or to so arrange to be relieved of certain of my work as to have more time available to put into the research. Yet it is a line of work that in the long run should bring exceedingly valuable results. If the suspected relation of peach yellows and little peach to the mosaic type of disease can be proved we will have taken a long step towards the solution of the elimination of these diseases. Indeed, it seems to me rather a reproach upon this institution that these two diseases, among the most serious peach troubles known anywhere, have been left untouched for so many years.

I wish to call attention again to the great importance of a plant disease survey in Michigan in order that the more serious diseases may be caught in their incipiency and that furthermore the most important problems, i. e., those most in need of solution may be discovered. It is extremely regrettable that the limitations of funds are so great that we cannot get out into the field more, so as to learn by personal observation the practical questions that need to be solved. The County Agents bring many things to our attention but they are very busy along other lines and are not trained plant pathologists and so cannot recognize these troubles until they are very serious. The most serious fault of having the extension work so sharply marked off from the investigational work is that it cuts off many of the points of contact that formerly existed between the investigator and the farmer. I still maintain that the man who can explain a plant disease and its control to a farmer most efficiently is the man who knows the disease first hand, and not a man whose knowledge of it is hazy or at best second or third hand. Furthermore, while the investigator is out in the field explaining and demonstrating he is also being given an opportunity, very much needed, to get into contact with methods of actual farm practice which may enable him to work out control methods that are practicable.

I wish to call special attention to the work that Dr. Hibbard is carrying on. For several years he has been engaged on the investigation of the physiological phenomena of absorption of mineral nutrients by plants and of the best balance to be maintained between these nutrients in the solution. Having verified the results obtained by certain investigators and discovered certain other points himself he is now taking the next step, that of attempting to apply his knowledge to the study of plants growing in the soil. It seems as if he has devised a method by which it can be predicted with some degree of assurance what types of fertilizers must be used on the soils under investigation. It is unsafe to say that this method will work for all types of soils, for but few have been tried, yet the beginning is very promising. I regret especially that the shortage of funds was such that he has not been able to have a well trained man to assist him in the cultural work which, if the investigations are to be pushed, requires a lot of time in preparing culture solu-

tions, setting up cultures, measuring and weighing plants, recording results, etc. Dr. Hibbard has employed students to help in this, but their time is not always at his disposal when it is most convenient for him to use them. It is therefore highly desirable that such a trained assistant as mentioned above be employed at the earliest opportunity.

I append herewith the reports of Dr. Hibbard, Mr. Muncie and Dr. Coons, on their work for the past year as well as five brief supplementary reports. I urge that you attempt to arrange that my report together with all these appended reports be issued together as a reprint from the Board Report and that 500 copies be furnished to this division for distribution among persons interested.

Respectfully submitted,
ERNST A. BESSEY,
Botanist.

East Lansing, Mich., June 30, 1917.

PLANT PHYSIOLOGY.

Prof. E. A. Bessey, College:

Dear Professor Bessey: At your request I herewith submit the following report of the work in Plant Physiology for the year ending June 30, 1917:

No change has been made in the distribution of the time between the College and the Station. Approximately 3/5 of the time has been devoted to investigation and 2/5 to teaching. It is appreciated by the writer that there is another phase of endeavor open to the plant physiologist in the line of extension work, but as yet this field has not been touched for various reasons. It has been acknowledged by a few for some time back and now many are awakening to the fact that the extension specialist is dependent on the results of the experiment station work. Many lines of investigation have suffered as a result of present economic conditions to such a degree that the National Research Council has especially emphasized the importance of continuing all research as before. Unless funds and a trained assistant can be obtained to carry on station work it would be unwise to make more than a newspaper campaign along extension lines. This has been done from the beginning of the present extension publicity work. The writer has talked with a few extension leaders and county agents and all agree to the necessity for work in plant physiology and some of the county agents' problems have been discussed.

All the investigational work for the station has been supported by the Adams' Fund and is being conducted along the same general lines and under the same title as proposed in April, 1915, namely, "The absorption of solutes by plants with especial reference to balanced solutions." By way of brief summary, the following may be said in regard to the progress made in this investigation since the last report.

Repeated experiments with a three-salt nutrient solution under different sets of conditions have shown that the conclusions drawn by Shive in regard to its suitability and efficiency when compared to all other

nutrient or standard solutions are well taken. It is likely that this solution will supplant the four, five, or six salt solutions, since it contains every one of the elements said to be absolutely essential, and simplifies the routine work necessary for a study of salt ratios. There has been considerable criticism of water culture methods in general, and some of these have been well founded. Most of the work already published on the matter consists of but little more than growing plants in different solutions and recording the differences in height and judging a plant from a few other merely qualitative criteria. The work should be more scientific and an attempt be made to analyze the results produced on plants such as the effect on the physiological processes, etc. Sand, soil, and field studies should be made and a practical application brought to the front. The lack of control methods becomes more apparent as field studies are approached and this is where but little work of a quantitative nature has been done.

In regard to salt ratios or physiological balance, it is true that some ratios in a single series cause better growth than others, and one can be found better than any other but no two or more series of cultures seem to agree on any one set of the ratios. However, it can be said that they are located near each other in the same restricted area. Variations in individual plants, difference in vigor, susceptibility, and different environmental conditions might account for this lack of identical agreement. The problem is open for further study.

In regard to solute absorption in distilled water nutrient solution, this much may be said. Cryoscopic and conductivity determinations have shown that where the ratios are such as give the best yields in wheat the concentration of the solution has been reduced the most and when the ratios have given the poorest yields the concentration has changed but little, all of which leads to the belief that the optimum ratio or physiological balance tends towards a more efficient absorption.

From the work with distilled water, the next logical advance would be studies with the soil solution. The soil solution was supplied by the Bacteriological Department, through the courtesy of Mr. Morgan, who cooperated in this investigation. The subject matter has been brought together and is ready to be passed on for publication under the title, "Physiological Balance in the Soil Solution."

The soils, one fertile and one infertile, were extracted. These two different solutions formed the basis of three experiments. The solution from the poor soil possessed a low initial concentration and was treated with all possible ratios of three salts varying in increments of 10 percent. This study showed what ratio of salts in this particular soil solution gave the best growth and greatest yield, and when compared with the best ratio in a distilled water culture showed that an excess of potassium and phosphoric acid was beneficial. When acid potassium phosphate in the dried form was added to a sample of soil similar to that from which the solution was extracted it gave a yield of wheat considerably above the control. This seems to show that a study of the soil solution indicates the chemical needs of the soil from which the solution was extracted.

Next the good soil solution was treated in the same manner. Its initial concentration was high. A different ratio of salts proved to give the highest yield. When compared with the ratio in distilled water cul-

tures it was learned that calcium nitrate was necessary. When this was added to the dry soil the yield was considerably greater than in the control.

A third experiment consisted in using the good soil solution but at a much reduced concentration. The initial concentration was the same as that possessed by the poor soil solution. Here a different ratio accounted for the high yield but it still showed as above that the soil needed calcium nitrate.

The next step in the work is obviously a consideration of soils. The problem becomes complex as there are so many conditions not under the experimenter's control, such as variations in physical, chemical and biological properties. Each of these is being considered step by step and a simplification attempted. Chief among the conclusions now drawn is that in one particular soil used, there is a best or optimum ratio of salts and this is the basis for testing out the possibilities of determining a rational system of fertilization of soils from the point of view of balanced solutions. It is expected that this study will take considerable time. A great many data have been collected and are being put into shape for publication.

There is need of further assistance in this work both in the line of a trained man, and money for running expenses. Teaching breaks in and interrupts the undivided and continuous attention needed in this work. From May to September is the only time that the writer can put in continuously on this work. Next year, since there will be more teaching to do, this time will be shortened. It is urged that some assistance be obtained.

Other problems are pressing and some have been crowded in, but on account of lack of time and the desire not to interfere with the regular Adams work, most of them have had to be abandoned. I refer to the following problems: Physiological studies of the effects of poisons on plants, with reference to their use in the eradication of Canada thistles, wild mustard, etc., from fields; nutrition as related to physiological diseases; water requirements of plants; plant growth in relation to climate for the purpose of determining regions in the State more suitable for certain crops than the present ones; an ecological-physiological study of peat and muck soils in order to make available a greater acreage in the State for greater production.

My work in the College includes under-graduate and graduate instruction. This has continued along the same lines as before. It is gratifying to report that the work is enlarging in scope, reaching a greater number, overtaxing the capacity of the laboratory and taking more of my time then usual. Mr. H. C. Young who took the place made vacant when Mr. G. R. Johnstone resigned, has handled the laboratory work exceedingly well and to his enthusiasm and efforts is due much of the success that has been attained this past year. No little credit is due, however, to Messrs. Kettunen and Kelham, advanced students in plant physiology, who so ably assisted us in the winter term when the class had to be divided and the laboratory sections taken at different times. Following the plan that has been in vogue the past four years two lectures were given this year to the class in Agricultural Chemistry.

More laboratory space in the Experiment Station and new greenhouses are urgently needed.

I wish to thank you also at this time for your willing cooperation and assistance in all the varied interests of Plant Physiology.

Very respectfully,
R. P. HIBBARD,
Research Associate in Plant Physiology.

PLANT PATHOLOGY.

Dr. E. A. Bessey, East Lansing, Mich.:

Dear Sir:—At your request I submit a report of the work done during the past fiscal year. The allotment of my time in part to the college and in part to the Experiment Station continued as before. The work for the college is divided into several forms of activity; teaching classes in Plant Pathology, assisting with graduate work and assisting in the extension phase of the department's work. The statistics of the undergraduate and graduate teaching form a part of your departmental report.

The extension work has consisted, in part, of attention to correspondence with reference to plant diseases. During the year from 800 to 1,000 specimens have been determined. Several popular addresses on plant diseases have been given at farmer's institutes. I have also appeared on the programs of the annual meetings of the Michigan State Potato Association, Michigan Ginseng Growers Association, Michigan Vegetable Growers Association and the Michigan Horticultural Society.

In extension work three projects have been framed for cooperative endeavor with the county men. The titles, present status (July 15, 1917), of these projects are as follows:

I—The Control of Grain Smuts.

Object:

1. To bring the treatment of seed oats and seed wheat into more general use.
2. To secure accurate data on a state-wide scale of the actual results of the extension work on this project.

This project has met with enthusiastic cooperation from the county men. In many cases it merely supplemented work already being conducted in the various counties. The work done by the department consisted in providing "copy" for extension circulars, form letters, etc. Lack of funds prevented any publication of circulars or other matter. However, the county men by means of lectures and by personal letters to the farmers in their respective counties have secured wide spread utilization of the formaldehyde control measures. As a supplement to this report the oat smut circular which was mimeographed and sent to county men is published. At present the data from druggists are being obtained to determine the sales of formaldehyde in the various counties. Beginning about August 15th the campaign on wheat stinking smut will be started.

II—Celery Disease Control Demonstration.

Object:

(A) To demonstrate the advantage of,
(1) of seed bed rotation and sanitation in field and greenhouse.
(2) of seed treatment.
(3) of spraying to control leaf diseases.
(4) planting resistant varieties on soils infested with the celery stunt organism.
(5) of exclusion of plants from diseased or suspected localities.

(B) To carry on an educational campaign with growers to familiarize them with the points of the above outline in order to make permanent advance and lead to the completion of the project.

(C) To improve marketing conditions in so far as they concern celery diseases by,
(1) improvement and standardization of an open crate of uniform size and pack.
(2) improvement of shipping conditions in order that crates of celery will not be rotted on arrival at market.
(3) assisting in the marketing of resistant varieties of good quality.

This project is a natural outgrowth of the experimental and demonstration work done on celery diseases the last two years. The field work already done has largely been in the hands of Mr. Ezra Levin and such advance as has been made is to his credit. Last year was a year when celery blight threatened to be serious. Mr. Levin who was working on a summer appointment for this work was able to predict that an epidemic was threatening and was able to induce the majority of growers seen to spray. In one month he secured the sale of more than 150 sprayers. A visit to the growers to whom this extension work has been carried shows that permanent results in the way of improving cultural practices have been obtained.

The "Easy Blanching," a green celery which is largely immune from the stunting disease, is being substituted for the "Golden Self-Blanching" celery at Kalamazoo. The use of this variety for "sick" soil is being widely advocated and assistance in marketing will be given.

III—Demonstrations and extension service in the elimination of losses due to transportational diseases.

Object:

1. To demonstrate the importance of careful grading, packing and elimination of diseased fruits and vegetables in carload shipments.
2. To teach at the car door proper methods of handling perishables as to pack, type of containers, sorting of stock, etc., in order to avoid loss from disease in transit.
3. To teach, basing the work on the needs as shown by carload inspection, proper methods of orchard and field control

of plant diseases in order that diseased fruits will not be presented for shipment.

The work done on this project consists of two months' observational work done at Chicago with Michigan produce. Mr. Ray Nelson, graduate assistant, was stationed in Chicago in September and October, 1916. Notes were made on conditions of cars and pictures were taken of typical examples of loss from transportational diseases. Although observations were not made when the shipping season was at its height enough was seen to prove conclusively we have here one of the great leaks in Michigan agriculture. Many shipments arrive in good condition and show no loss. Others arrive and are subject to great depreciation. In part this is due to faulty handling in the field or shipping point. This project aims to make possible extension work with just this class of shippers who are having trouble and who need advice. It is proposed to station a man in Chicago to report losses to the department and attempts will be made to advise such shippers through the county men.

The work done for the experiment station falls under three heads, namely that done under the (1) Adams fund project, (2) the Hatch fund projects, (3) and the various state fund projects.

THE ADAMS FUND PROJECT.

The formal statement of this project is as follows:

To determine with some plant pathogenes of the Fungi Imperfecti, biological relations which may give a basis for identification and classification as well as understanding of physiological and life history problems. The Fungi Imperfecti form a group which at present has no basis for classification other than a highly artificial one. Attention will be concentrated on the section of the group represented by the genus Phoma and its close allies.

Attempt has been made to utilize the methods of diagnosis in use in Animal Pathology in the solution of the problems involved in this project. The work has been in cooperation with the members of the Bacteriology Department, which has furnished excellent facilities for the research and has given helpful advice throughout. A start has been made in outlining the methods to be followed and enough has been accomplished to show the soundness and feasibility of the proposed method of attack.

It has been shown already in a preliminary way, that differences in the protein content of fungi can be used for diagnostic purposes. For example animals sensitized with a given species of fungus show anaphylactic shock on subsequnt inoculations with the same species, but no reaction with a different species.

With a certain fungus, (the Fusarium causing aster wilt) aside from the anaphylactic shock, a peculiar type of posioning occurs. Animals injected with a sufficient dose of ground mycelium and spores become emaciated and die in 10 to 12 days.

Many animals show a natural sensitiveness to Fusarium injections. The explanation of this has not been determined.

In early experiments some injections were made with ground mycelium which had been preserved by the presence of phenol in 1% dilution. Although less than ¼ cc. of the 1% solution was injected in 300 gram guinea pigs marked results were obtained after two minutes which greatly resembled anaphylactic reactions. There is a possibility that phenol or other disinfectant poisoning has been a factor in many experiments, since it is common practice to preserve antigens in some such manner.

This project on which a good start has been made will require considerable time for completion.

HATCH FUND PROJECTS.

Plant Disease Survey:

The work under the Hatch fund has continued along the same lines as in previous years. The plant disease survey of the state has been continued. In making this survey the extensive correspondence of the department already referred to was found to be an invaluable adjunct.

The work of the plant disease survey has been further carried on by means of questionnaire letters and by field trips to various parts of the state. The tabulated results of this survey have been forwarded to the Bureau of Plant Industry at Washington. Some of the interesting observations and reports of new diseases are briefly mentioned in a supplementary article in this report. (Supplement 3.)

Cereal Smuts:

Preliminary to the extension project on smuts outlined at the beginning of this report certain work was undertaken to test the efficiency of various formaldehyde treatments.

Our attention had been called by Dr. M. F. Barrus of Cornell University to the new method of treating grains for smut which has been developed by Mr. R. J. Haskell of his department. In this treatment the grain is spread in a long pile and sprayed with *concentrated* formaldehyde at the rate of one pint to 50 bushels of grain as it is shoveled over. For spraying a small pint or quart atomizer is used. The grain is then covered. After four hours, the grain is spread and aired. The treatment is applicable to all grains but for use with wheat the grain must first be thoroughly fanned.

It will be seen that this method presents great advantages because it eliminates the wetting of the grain which has hitherto been considered essential to effective action of formaldehyde.

The following tests of the method were made: Viable spores of oat smut were dusted on a couple of quarts of ordinary oats such as would be used for planting. These were then sprayed with concentrated formaldehyde at the rate of ⅓ of a c. c. to a quart of grain, (approximately 1 pint to 50 bushels.) The grain was stirred throughout the treatment. The accompanying table indicates the length of time the formaldehyde was allowed to act, and other conditions imposed in the experiment. The spores were washed from the grain and thrown down with the centrifuge. They were then tested in Van Tieghem rings for germination.

Time.	Oats in tight jar.				Oats in sack.			
	Concentrated Formaldehyde.		Dilute Formaldehyde 1-320.		Concentrated Formaldehyde.		Dilute Formaldehyde 1-320.	
	Germination.		Germination.		Germination.		Germination.	
	Oats.	Smut.	Oats.	Smut.	Oats.	Smut.	Oats.	Smut.
15 min	94	Strong..	98	60%	94	Strong..	100	70%
38 min	100	Weak..	100	Strong..	100	Weak..	90	Weak.
60 min	Not tested	Weak..	Not tested.	Strong..	Not tested.	Weak..	Not tested.	Weak.
2 hrs	96	Weak..	88	Strong..	92	25%	96	Strong.
4 hrs	94	0	98	None...	94	None...	98	None.
6 days	86	0	Not tested.	Not tested.	88	None...	Not tested.	Not tested

The experiments show that in reaching smut spores the gas in the concentrated method is probably as efficient as in the dilute or sprinkling method. The spores are probably killed in sufficient numbers after one hour to make the treatment safe, even with such a short time. Four hours is a safer time. Viability is but slightly affected, even after 6 days in a tight glass jar. The oats may be sacked immediately after treatment without loss in efficiency.

The last possibility is very important in that it allows the treatment to be applied in elevators to large stocks of grain. Two or three men could treat a large supply of grain very readily and in a short time.

Examination (July 15, 1917) of fields of oats, barley and wheat in Kent county, treated by the concentrated formaldehyde method show no reduction in stand due to treatment. In the case of oats there was no smut found in treated fields, but was present at the percentage of 1/3 of 1% in wheat fields treated by the concentrated method, 1-10 of 1% in fields treated by the ordinary dilute formaldehyde sprinkling method and in 2% quantity in untreated fields. The wheat was of the Red Rock variety and had been obtained from the same source. Reports furnished by Mr. H. G. Smith, Kent County Agricultural Agent, shows that in other fields in which the grain was treated by the concentrated method, the bunt was almost completely eliminated, only one or two heads being found in walking the entire length of the field. Evidently the personal equation and other factors, such as subsequent infection from sacks or drill, strength of formaldehyde, are operative in this treatment as in the well known sprinkling method.

Other work with the Hatch Fund:

Superintendence by Dr. Bessey of the cucumber disease project in which the department is cooperating with the U. S. Department of Agriculture has been carried out by the use of this fund. Research work on many minor problems is carried out by means of this fund.

The collection of photographs of plant diseases of the department has been greatly increased.

STATE FUNDS.

Bean Disease Investigations:

The work on bean diseases has continued along previously outlined lines. Work of the last fiscal year has been concentrated on the testing of seed beans from the western districts. Formal report on this investigational work is submitted by Mr. Muncie.

Potato Disease Investigations:

The work on the Fusarium Wilt disease of potato was continued throughout the summer of 1916 by Mr. R. W. Goss. While definite advance was secured in laboratory studies, following lines outlined in the 1916 report, the field work was greatly interfered with by the drought of July and August.

Fusarium wilt shows two aspects under Michigan conditions. The first is a rapid wilting in which the vine dies before the tubers are mature—usually only half grown. The second form manifests itself at the close of the growing season and may cause the dying of the potatoes in an entire field. The tubers from the potatoes showing the first type of disease are typically pointed at the ends and show deep Fusarium wilt markings. The tubers in the second aspect are nearly normal except for a slight browning or yellowing of the vascular system.

The observations of the last three years seem to warrant the statement that the first aspect of the disease comes when affected tubers are planted and the fungus grows from the mother tuber directly into the young sprout.

The second type of trouble comes about from invasion of the root system by the parasite followed by a tardy wilting and gradual invasion of the tubers. Tubers thus invaded produce the virulent type of wilt the next year.

Such observations coupled with the discovery of what seems to be *Fusarium oxysporum* in native Michigan soils accounts for the high percentage of infection which is present in our sandy fields and also points out why under conditions of drought (which leads to death of the roots) infection of the second type may occur in 90-100% of the plants.

A field of potatoes was seen at Cheboygan last year in which about 95% of the vines had wilted with Fusarium Wilt. Mr. H. L. Lewis, graduate assistant in the department was sent to Cheboygan to select what seemed Fusarium resistant hills from the plants which had remained alive. About 300 hills were secured and these have been planted in soil known to contain the wilt organism. It may sometime be possible to secure a resistant strain for planting which will combine with desirable varietal characteristics resistance to disease.

Work was also done on the Black Leg of potato. This disease is wide spread in the Upper Peninsula and is as yet extremely localized in the Lower Peninsula and apparently on introduced seed. Work needs to be done to show whether the germ can winter in the soil, and whether it can tolerate the climate of lower Michigan. A start on this work has been made. In experiments made so far in cooperation with the Bacteriology Department, the germ could not be isolated from soils heavily infested two months previously. The soil solutions were extracted by the oil pressure method and platings were made.

The results of the study of epidemics of Late Blight of 1912 and 1915 were reported before the Botanical Society of America in New York

City last December. An abstract of this article is included in this report. (Supplement 4).

Celery Work:

The investigation of celery diseases has been continued. The stunting disease, for which control measures were planned last year, became so serious as indicated in Mr. Levin's report, that steaming the soil as a clean-up measure became out of the question. A survey was made of the various marshes about Kalamazoo and the present extent of the disease was noted. The trouble is in nearly every field about the city. Floods and wet ground, along with exchange of plants, have been the chief causes of this wide transfer. Wet ground in July and August of 1915 especially favored the transfer of the disease by tracking, cultivation, etc. It is needless to say that the present plan of buying plants from various localities is especially dangerous because of soil diseases. Each grower should grow his own seed on clean ground.

The work on the Phoma disease of celery was continued and a report of the work was made at the annual meeting of the Botanical Society of America. An abstract of this article is included in the report. (Supplement 5).

It was considered advisable from financial considerations to lay to one side the experimental work on celery diseases during the fall and winter months. Accordingly some questions have not been investigated thoroughly. It is advisable that this project continue.

The division is cramped for room not only in the laboratory but also in the greenhouse. The growing needs of our work should be recognized in the building program of the College.

Respectfully,
G. H. COONS,
Research Associate, Plant Pathology.

PLANT PATHOLOGY.

Dr. E. A. Bessey, College:

Dear Doctor Bessey:—I submit herewith at your request a report upon the work done during the past year. This work has been carried on entirely under the state fund of the Experiment Station.

The work has been, as previously, principally upon control measures for the bean Anthracnose and bean Blight. The preliminary treatments of diseased bean seed with calcium hypochlorite solution gave seemingly promising results. Subsequent tests failed to prove the value of this reagent in controlling these diseases.

On the demonstration plats in fourteen counties where Idaho grown Michigan beans were grown in comparison to ordinary seed, the results were very satisfactory. It was found that the Idaho grown Michigan seed did not suffer in the least from being grown in the western state for one season. These beans produced on the average more than the ordinary seed produced. The crop from these beans was also less affected with Blight than the crop from ordinary seed.

The season was so dry that the Anthracnose did not develop to any great extent. As far as the latter disease is concerned, there was little difference between ordinary and Idaho grown Michigan seed.

Last year Early Wonder beans were grown at Jerome, Idaho, under irrigation. There beans showed a commercial pick of two pounds per bushel of diseased seeds. The crop showed no Anthracnose and less than 1% of the Blight. These results clearly show that Michigan beans can be freed from the Anthracnose, and almost entirely rid of the Blight by growing them in a hot, dry climate.

To demonstrate the value of this Idaho grown seed, plats are being grown, in cooperation with the County Agriculturists, by various growers in the following counties: Kent, Newaygo, Saginaw, Muskegon, Allegan, St. Clair, Kalamazoo, Cheboygan, Alpena and Ottawa. In connection with this project demonstrations of the value of hill planting as compared to row planting in the control of these bean diseases are being carried on by the growers. These demonstrations are being duplicated on the College experimental plats.

A girdling of bean stems at the nodes has been increasing in seriousness. This trouble has been proved to be caused by Bacterium phaseoli, the causal parasite of the bean Blight. Preliminary field experiments show that the bean Blight bacteria are carried by the wind, and that infection spreads from individual diseased plants. Further field experiments on the dissemination of this disease are under way.

The results of three years' work on control measures for the bean Anthracnose and bean Blight have been put into bulletin form. This manuscript is now being revised preparatory to publication.

Michigan grows a large acreage of peas for canning purposes and for seed. In 1914 a bacterial disease of peas was reported from Newaygo county, specimens sent in to the department and the casual organism isolated. This disease is reported from Wisconsin, Idaho, Montana and Colorado, where most of the seed is grown. It was found in this state that peas from Idaho and Montana seed were affected in varying degrees by this bacterial disease, while in only one case was it found in a field of Michigan grown seed. If we are to protect our pea industry from this disease, which in many cases destroyed whole fields this year, the origin of the disease on the seed should be found and canners warned to not use seed from infected areas.

The Septoria and Ascochyta diseases of pea leaves, stems and pods are prevalent this year, although the damage to the green crop is not severe. A root rot caused by Rhizoctonia is causing a great deal of damage to peas in practically every locality visited. This is to be expected in a year when the soil is so moist and the weather cool.

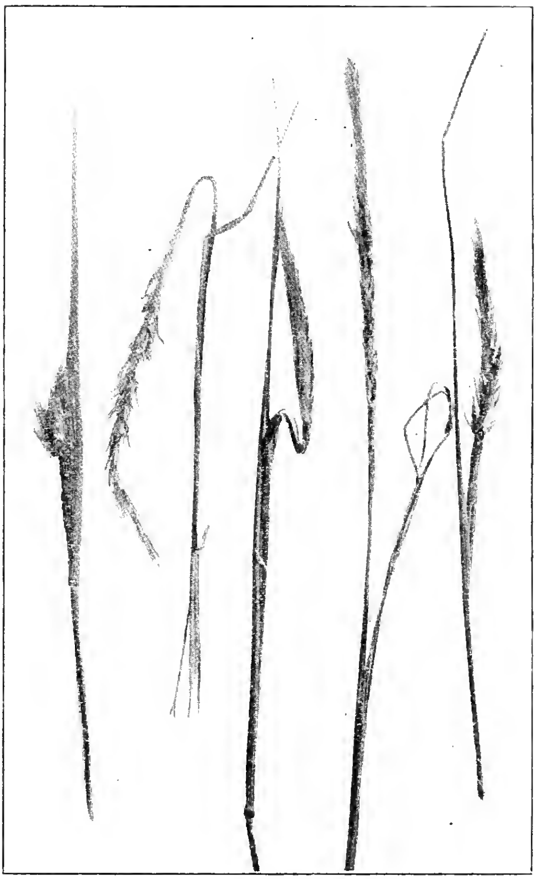
Cross inoculation experiments with the Ascochyta disease of vetch, sweet clover and peas are still in progress.

Very truly yours,
J. H. MUNCIE,
Assistant in Plant Pathology.

NOTES ON THE CONTROL OF RYE SMUT (Urocystis occulta).

ERNST A. BESSEY AND WALTER K. MAKEMSON.

In the summer of 1915 a specimen of volunteer rye was found near Laingsburg, Shiawassee Co., affected with a peculiar form of smut. In 1916 this smut was found in a field at Dimondale, causing a loss of at least 5%, and in fields in Kent, Ingham, Mecosta, Van Buren, and Osceola Counties, causing less than 1% injury. The disease has been reported from Australia as causing over 60% loss and in parts of Minnesota the loss from this disease reaches 25 to 40%.



Unlike the ordinary smuts of oats, wheat and barley this smut is not found to much of any extent in the head. It occurs in the culm, sometimes throughout its whole length but more often in the upper internode, i. e., in that part of the stalk just below the head and which in dis-

eased plants is often retained in greater part within the uppermost sheath. Before the spores are ripe the culm is somewhat swollen and more or less twisted and misshapen, showing black streaks which are the regions where the spores are present in great abundance. These streaks may be present even in the sheath or in the leaves. On cross section black areas appear corresponding to these streaks. The head either remains unchanged, except that it dries up, or may show distortion of the lower spikelets, these being filled with the black masses of the spores. As the spores ripen the swollen parts shrink and split open over the elongated spore masses, allowing the spores to escape as a black powder. This takes place just about the time for harvesting the grain. The diseased plants stool but little and are usually only two-thirds to three-fourths as tall as the healthy plants.

Three types of smut infection are now recognized by plant pathologists: (1) at all actively growing parts of the plant for a considerable period of the growth of the plant, as in corn smut; (2) at the blossoming period of the plant, the fungus growing into the developing seed within the flower without destroying it and keeping pace with the growth of the plant that grows from the seed, not becoming visible externally until shortly before the time of flowering when the flowers and often all the adjacent parts are found to be filled with the spores of the smut, to the total destruction of these parts, as in the loose smut of wheat and barley; (3) just as the seedling is emerging from the seed, infection occurring from spores of the smut that have remained attached to the seed when it was planted or that were in the soil, as in oat smut or bunt of wheat.

The location of the smut infection throughout the rye plant instead of merely at the growing regions, indicates that the rye smut does not have the first type of infection. In the summer of 1915 Dr. G. H. Coons attempted blossom infections by dusting fresh spores of this smut upon the heads of rye as they were in blossom and by rubbing the spores into the spikelets, planting the seeds obtained from these heads in the Botanical Garden. In June, 1916, these plants were absolutely free from the smut, showing that no blossom infection had taken place. This was to be expected from the fact that the spores are not shed at the blossoming period of the rye but at harvest time. In the meantime a bulletin was issued by the Minnesota Experiment Station* stating that the infection was of the third type, i. e., seedling infection. This bulletin was not yet at hand when the following experiment was begun to determine this point. On September 23, 1916, seeds of Rosen rye obtained from the Department of Farm Crops of this institution were treated with spores of the rye smut freshly scraped from diseased culms collected by the senior author in July and August. The treated grain was planted in the Botanical Garden in rows about seven feet long and a foot apart. About 100 plants came up in each row. The treatments of the seeds were as follows:

Row 1—No smut spores, no disinfecting treatment; control row.
Row 2—Dry seed rolled in dry spores, no disinfecting treatment.
Row 3—Wet seed rolled in dry spores, no disinfecting treatment.
Row 4—Like row 1; control.

*Stakman, E. C. and Levine, M. N. Rye Smut. The University of Minn. Agri. Exp. Sta. Bul. 160, 19 pages, 6 figures. Aug., 1916.

Row 5—Seeds wet with weak gum arabic mucilage and rolled in dry spores, no disinfecting treatment.
Row 6—Seeds not treated, but the smut spores scattered on the surface of the soil and slightly worked in.
Row 7—Like row 1; control.
Row 8—Dry seed rolled in dry spores and subsequently treated for two hours with formaldehyde solution (one part of "40%" formaldehyde solution in 500 parts water).
Row 9—Wet seed rolled in dry spores and disinfected as in 8.
Row 10—Like row 1; control.

As stated above each row produced approximately 100 plants, although this could not be determined with absolute accuracy because of the fact that the plants were in some cases so closely grown together that it could not be told whether a certain cluster of culms represented one or two plants. The smutted plants, however, mostly had but one or two culms and so were counted with accuracy. In the following table the number of smutted plants in each row is given and the percentage of such plants, assuming the total number of plants in each row to be 100.

Row 1—Smutted plants 0, percentage plants smutted 0 (Control)
Row 2—Smutted plants 11, percentage plants smutted 11
Row 3—Smutted plants 17, percentage plants smutted 17
Row 4—Smutted plants 0, percentage plants smutted 0 (Control)
Row 5—Smutted plants 25, percentage plants smutted 25
Row 6—Smutted plants 0, percentage plants smutted 0
Row 7—Smutted plants 0, percentage plants smutted 0 (Control)
Row 8—Smutted plants 0, percentage plants smutted 0
Row 9—Smutted plants 0, percentage plants smutted 0
Row 10—Smutted plants 1, percentage plants smutted 1 (Control)

These experiments demonstrate that the infection takes place at germination or very shortly afterwards and furthermore that formaldehyde treatment of the seed such as is practiced for oat smut or bunt of wheat will control this disease also.

OAT SMUT.

BY G. H. COONS.

THE DISEASE.

Oat Smut is a fungous disease in which the whole head becomes a mass of brownish black powder. No grain is formed. Smutted plants are usually stunted and hence often overlooked in the field.

THE CAUSE OF THE DISEASE.

This disease is caused by a parasitic fungus—a small plant which makes no food for itself but steals its living from the oat. The body of the smut fungus is made up of threads microscopic in size which live inside the oat plant, growing up with it, and finally producing its own kind of fruit where the oat kernel should be produced. This fruiting mass of the oat fungus is the brown smutty powder. It is made up of countless thousands of exceedingly minute balls. These balls are the "seed" of the smut fungus. They are called spores.

THE COURSE OF THE DISEASE.

These seedlike bodies, the spores, are mature at threshing time. The air about the machine is sometimes black with them, and the smut rises in clouds. They get into the crevices of the grain and entangled in the bristles. When the grain sprouts, the smut fungus sprouts too and bores into the young seedlings. Smut treatment kills the spores ("seeds" of the smut fungus) on the grain without hurting the oats. *Smutted oats give smutted plants, disinfected oats give clean, healthy plants.* When the oat matures, the smut which has bored into the plant and which has been keeping pace with its growth, matures too. The same story is repeated year after year, at an enormous cost to the farmer's pocketbook.

LOSSES CAUSED.

It is not too much to say that year in and year out, smut destroys 5 to 10% of the Michigan oat crop. This amounts to nearly a million dollars annually. The oat smut's board bill costs the average farmer with 10 acres of oats $50.00 a year. He pays more to keep this parasite than he pays for schools. What the average farmer loses in one year from Oat Smut would pay his share in the tax that supports the Michigan Agricultural College 300 years. If the Agricultural College did nothing else than tell the farmer the well known facts about Smut, its existence would be justified!

OAT SMUT IS ENTIRELY PREVENTABLE.

Clean the oats of all weed seeds, chaff, and light grains by means of a fanning mill.

Fight oat smut either by the well known sprinkling method or by the new concentrated Formaldehyde Treatment devised by R. J. Haskell of Cornell University.

SPRINKLING METHOD.

Mix one pint fresh Formaldehyde with 40 gallons water. Clean a place on the barn floor and sprinkle with this solution. Spread the oats in a thin layer (4″) and sprinkle with the dilute solution of the Formaldehyde. A sprinkling pot is handy. Shovel over and over until every kernel glistens with moisture. Add layer after layer, sprinkling as before. Two men can do the work quickly and easily. When all the grain is moistened shovel into a compact heap, cover two hours with a blanket or canvas.

Then spread out to dry.

Do not let the wet grain freeze, mould or sprout.

The grain may be planted as soon as it is dry enough to run through the drill. Make allowance for the slightly swollen condition. One pint of formaldehyde will treat 50 bushels.

The treatment may be modified by dipping the grain one-half to one bushel at a time in a barrel or tub of the dilute solution. Drain, cover for two hours, dry and the oats are ready for planting.

THE NEW CONCENTRATED FORMALDEHYDE TREATMENT.

Use Formaldehyde at the rate of 1 pint to 50 bushels of grain. Put the amount of fresh formaldehyde, just as it comes from the druggist, into a pint or quart hand sprayer (cost 75 cents) and spray the grain which has been spread out on the barn floor. Spray the grain as it is shoveled over and over. Keep the sprayer close to the grain and the penetrating odor of the Formaldehyde will give no discomfort.

When the right amount of Formaldehyde has been applied shovel the oats into a heap and cover for exactly four hours with a canvas or blanket, or the grain may be sacked immediately.

The grain should then be spread out for a few hours' airing.

It may be sown at once, or stored in clean or disinfected sacks.

NOTES ON SMUT TREATMENTS.

With either treatment, avoid reinfecting the grain with old sacks or with the drill. To disinfect the sacks soak in Formaldehyde 2 tablespoonfuls to a pail of water. To disinfect the drill, pour this solution through it. The cost of treatment is less than 2 cents a bushel. Ask your druggist for fresh Formaldehyde.

The patent smut cures contain Formaldehyde as their active agents. Formaldehyde costs 35-40 cents a pint, the smut cures cost $2 or more a pint for a weak formaldehyde solution. Do you see the point?

NOTES ON MICHIGAN PLANT DISEASES IN 1916.

BY G. H. COONS.

The weather of 1916 was peculiar. The months of April, May and June were especially rainy. All farm operations were badly interfered with. Rains occurred in May and June every two or three days. Even the sandy lands ordinarily enjoying excellent natural drainage showed troubles such as are associated with water-logged soil. July and August, throughout the state were as dry as the preceding months were wet. An unprecedented drought cut short all crops. In spite of this dry season which effectively checked many plant diseases, some crops suffered great losses.

The prevalence of such diseases as Black Rot of grapes and Apple Scab, which are considered diseases associated with wet seasons, in a period of drought such as occurred last year, emphasizes the importance of the weather at the time of primary infection. This matter is extremely important in dictating all policies in control of diseases of this character. In May and June the plant diseases which winter on trash from the preceding diseased crop became established and many successive generations of spores greatly augmented the size of foci of the disease as well as established new foci. We may look upon the fungi as thoroughly entrenched as a result of such favorable weather conditions and in spite of the succeeding dry weather they were able during light showers and heavy dews so heavily to inoculate the tender fruits and leaves as to produce serious disease conditions.

TREE DISEASES.

Spruce:

Specimens of spruce have been sent to the laboratory covered with unsightly lichen growths. While in no case was definite injury to the trees noticeable the condition made the trees unsightly and to appear as if unthrifty.

Such complaints on various forest and fruit trees have come from a variety of sources and usually from localities close to bodies of water. Low areas, poorly drained sites, and wet seasons are largely responsible for the conditions favoring lichens. With fruit trees, failure to prune is a common cause. Where the conditions warrant, a dormant spray of lime-sulphur and summer sprays as recommended for apple are effective in cleaning up the trunks. These have been successfully used in several instances.

Catalpa Leaf Spot:

Catalpa leaves were sent to the laboratory from near Adrian and some were collected at Ann Arbor and also at East Lansing showing small circular spots about 5 mm. in diameter. These spots occurred in great numbers on the leaves and gave the trees a very unsightly appearance. Excessive dropping of the leaves did not occur however. This disease had associated with it *Phyllosticta catalpae* and an Alternaria. It is undoubtedly the same one which Galloway described in 1887. (Dept. of Agr. Report, 1887).

GRAPE DISEASES.

Grape Black Rot appeared as an epidemic in Michigan vineyards last season. Here there seemed to be a contradiction to the common belief that the Black Rot is synchronous with a wet season. At Lawton and Paw Paw in spite of a drought condition the grapes rotted so badly that there was only half a crop. The matter is clearly explicable if it be remembered that the virulence of early infection controls the later outbreaks. Infection of grapes occurred in May and June on account of the excessive rainfall. Spraying applied, as per rule, could not be timely. As a result, abundant leaf infection and abundant infection of berries shortly after the blossoming occurred. In the early half of August the bunches showed great promise, aside from the fact that small black rotted berries persisted from the early infections. A heavy rain about July 26th and another about three weeks later caused the loss of the crop. A few growers whose sprayings were timely so as to give protection at the first rainy period had a good crop. In general the crop was a disappointment. Vineyards in good sanitary condition showed less rot than neglected ones.

Sun scorch of leaves and fruits occurred last year. These troubles all show the general characters of this type of disorder, yellowed leaves with brown, parched edges, but are hard to diagnose and erratic in occurrence.

Lightning injury was reported by one grower as a common occurrence in grape vineyards. Lightning striking a wire will kill grape vines along the wire for several rods. The electrocuted vines wither slowly and present a confusing train of symptoms.

ROOT ROT OF STRAWBERRIES.

Strawberry plantings last year showed almost a complete failure in many fields. Reports of trouble were received from at least six counties. The plantings made at the College with first-rate plants failed to give a good stand.

The cause of this is hard to explain. It is certainly associated with the wet season at planting time. The roots of the plants failed to start and merely rotted. Microscopic examination showed Rhizoctonia on the roots. It is believed, however, that the soggy soil conditions lead to the rotting of roots rather than that a new active parasite had developed.

PEACH DISEASES.

Powdery Mildew is a disease common but not usually reported as severe. It was sent in by a correspondent from Oceana County. It was reported as causing injury to the crop.

Because of the cold wet April, Leaf Curl defoliated many orchards in Michigan last year and caused much loss to the growers. In spite of the well known control measures, the necessary spray is neglected by many fruit growers.

Cercospora circumscissa was very common last year. Peach leaves have been received from many localities showing the characteristic red spots of this disease. An orchard near South Haven showed the disease so severe that the trees were nearly defoliated at picking time. While the loss is difficult to estimate the wasting nature of this disease is apparent. Summer sprays are peculiarly effective in control of this trouble.

RASPBERRY CURL OR YELLOWS.

Red raspberries affected with Curl or Yellows have been sent from several localities in the past few years. Affected plants show curled, distorted leaves with prominent grooves at the leaf veins. The fruit from diseased plants is scanty and poor in quality. Commonly only a few carpels develop fully. This disease is potentially a serious one and instances are reported where entire plantings have been ruined.

POTATO DISEASES.

The common potato diseases previously known for the state were found in their usual prevalence. Potato Scab was seen everywhere as well as a type of trouble caused by Rhizoctonia which is commonly confused with Scab. In the later type of trouble no corking of the skin develops, the scabbiness showing as a black scurfy patch, commonly marked or colored with cross lines. This developed on the crop grown from treated seed on soil which had not borne potatoes previously. The evidence seems to point to the existence of Rhizoctonia as a common soil denizen and that the virulence of the soil form is less than that carried on the tubers. Under peculiar soil conditions the ordinary soil forms take on some pathogenicity.

Late Blight was not found at all as would be expected from what we know of the relation of this parasite to a cold, wet July. The drought was effective in preventing the appearance of the parasite in any noticeable degree. It must not be expected, however, that the disease has been wholly eliminated from our seed stock, for undoubtedly enough leaves have become affected and a few tubers have slight spots, readily overlooked, to insure the development of the fungus in another season if the weather in the first half of the growing season is propitious.

Fusarium Wilt was found everywhere stunting the plants and leading to marked yellowing and wilting of the tops. It would seem that the extra demand for water under the drought conditions in addition to the systemic poisoning which occurs in this disease was responsible for the development of this symptom.

Early Blight developed in the northern part of the State but was largely absent in the southern half of the State. The weather in the north was hot but the rainfall was moderate. In the southern portion the extreme dry weather led to tip burn with little or no development of early blight. This adjustment to weather has largely been borne out in previous years' experience in this state and we look at Late Blight as a disease which appears when the first half of the season is cold and wet, Early Blight when the season is moderately wet—its effects in wet seasons being obscured by Late Blight—and Tip Burn when the season is dry and the fields parch.

Black Leg was found commonly in the Upper Peninsula but was not reported from the Lower Peninsula, although the weather of May and June would have insured its development, had the disease been present in the tubers. Up to date, only one case of Black Leg has been reported for the southern counties of Michigan and this one in stock imported from the north. It is not known whether this disease is climate limited or has merely not been introduced.

Streak, a disease new to Michigan was discovered in fields near Cheboygan, Michigan, by Dr. Edson of the U. S. Department of Agriculture.

Only two or three plants were seen. The disease is characterized by dwarfing of the affected plants which show black streaks on stems and petioles and occasionally in the leaf veins themselves.

No Mosaic was seen last year although stocks which showed Mosaic the preceding year were examined. It is believed that weather conditions masked the signs by which we diagnose the disease.

TOMATO DISEASES.

Point Rot or Blossom End Rot was reported from many sections in the southern half of the state. The disease was clearly associated with drought conditions.

Many growers complained of failure of the blossoms to set fruit. This seemed to be associated with the unusual weather conditions at time of pollination.

CUCURBIT DISEASES.

Work on cucumber diseases was carried on as before in cooperation with the U. S. Department of Agriculture at Big Rapids. No serious epidemics of cucumber diseases occurred. Cucumber Scab occurred only in small amount, and cucumber Mosaic although present did not ruin the crop. No report of Downy Mildew was made. Considerable complaint was made on account of a Tip Burn or Leaf Scorching which was undoubtedly to be ascribed to the drought conditions.

On seed farms near Jackson diseases of cucumber and muskmelon were very important. Anthracnose on certain varieties of muskmelon (Empress) destroyed the crop. Anthracnose on the cucumber fruits, which has not been reported commonly, occurred in sufficient amount to greatly lessen seed production.

Angular leaf spot was found in many localities and was described by correspondents as doing severe injury to seedlings.

A disease caused by a yellow bacterial organism was also sent to the station. In this disease brown watery spots occurred on the fruit, usually associated with a lenticel. From such diseased spots beads of dark reddish brown gum emerged. The affected fruits softened and rotted in the course of a few days. The organism was obtained in pure culture and characteristic lesions produced by inoculation experiments. The germ seems distinct from *Bacillus lachrymosus* and from the organism described by Burger as causing rot of cucumbers in Florida.

A new disease of watermelon was discovered by Mr. Ray Nelson, graduate assistant in the experiment station. Watermelons affected with this disease show blackened, withered spots commonly at the point where the blossom was attached. This spot increases in size until the whole melon may be involved. Usually the disease only progresses far enough to cause a blemish about 3″ in diameter. The cause of this disease is a Pythium, probably *Pythium debaryanum*. The causal organism has been obtained in pure culture, its pathogenicity proved, as well as its ability to attack fruits of other plants of the cucurbit family. The organism does not produce a "leak" of potato.

The disease has been observed in several fields. Its economic importance is not known. It will probably be found to be wide spread and serious, not only in Michigan, but in the centers of watermelon production. Mr. Nelson is continuing his observations on this disease. The fungus is being grown in pure culture in the laboratory and further publication is promised.

LETTUCE.

Anthracnose or shot hole of lettuce (*Marssonina panattoniana*) was reported but once in 1916. Formerly this disease occurred everywhere in Michigan greenhouses. At present its occurrence is only occasional, and then usually associated with leaky gutters. It would seem since it is known that the disease is readily dispersed by hose watering, that the diminution of this disease may properly be correlated with the increase in amount of overhead watering systems.

One case of the disease was found in a garden near the College. The plants were grown on soil which had never before borne a lettuce crop and from one plant the disease spread along the row. No wild lettuce grew near. In absence of any report of the fungus on other hosts, the possibility of seed transference seems probable.

Lettuce Stunt:

In the 1915 Report of the Michigan Academy of Science I described a new disease of greenhouse lettuce which is at present commonly ascribed to Rhizoctonia injury. In that publication it was presumed that bacteria stand in causal relation to this malady. Repeated cultures failed to give any one bacterial organism with any degree of regularity. From bits of tissue in practically every culture attempted a rapid growing Phycomycete has been obtained. This organism is a typical Pythium. Time has not been available for inoculation experiments, but it seems likely that the disease found is associated with this known parasite.

Many circumstances contribute to this assumption. The disease is severe when seedlings are watered abundantly, and is checked when the seedlings are kept "on the dry side." Plants near leaky valves or leaky gutters may show the disease while the drier parts of the beds have sound plants. The disease is commonly contracted in the seed bed, but may arise from wet conditions in plants half grown, or even older. Since wet conditions seem to be essential to infection, the control is obvious. It has been put in practice with marked success by several greenhouses.

CELERY.

The Celery Stunting Disease increased in extent until practically no fields in Kalamazoo are free from infection. This came about largely from flooding. The wet weather of 1915 may have been important in bringing about greater dispersion by the tracking of mud from field to field. All second crop and third crop celery of Golden Self-blanching celery planted in affected fields was practically a failure. The disease was found at Grand Haven, Jackson, Bay City and Portage, Michigan. In view of the wholesale interchange of plants in celery districts, it is likely that the disease will be widely introduced throughout the state.

Celery Blight (*Septoria apii*) did enormous damage last year. The enormous infestation of the first crop which occurred on account of the wet weather in the early half of the season, brought about considerable infection of the second crop. Heavy rains in the fall in conjunction with the scattering foci of disease which existed, led to an epidemic of great severity in all the celery districts. In the Kalamazoo district alone \$25,000 in claims were filed against a railroad company for rotting in transit. This was largely on second and third crop celery. As this rotting

came about largely from Septoria blight, aggravated by delays on the part of the carrier, some idea of the magnitude of the losses can be seen. Many growers did not try to ship their third (or main) crop. Celery as seen in the market was small, due to the trimming necessitated by the blighting of the outer stalks.

Early Blight was found doing enormous damage in the susceptible varieties of green celery, particularly Newell's Market. In many sections during the hot weather of July and August this disease and not Septoria was important. Spotting of the leaves and cankering of the stalks characterized the heavy infestations. The correlation of this disease with hot weather seems to fit the previously observed Southern distribution of the trouble.

LEGUMES.

Sweet Clover:

Ascochyta caulicola was found in several locations in Michigan. The pycnidia of the fungus were found on the old stalks of the preceding year, and their presence served as a source of new infection. At present sweet clover is not widely planted as a forage crop, but with increased use of this promising plant the Stem Blight may be very important. The fungus does not differ from that described by Laubert (Arb. Biol. Abt. f. Land. und Forstwirtschaft 3:441, 1903.)

Pea:

The Septoria disease of pea was found severe in gardens near the college. The disease appeared on the first leaves and quickly spread to the stems and eventually to the pods. While seed transference of the disease seemed likely, the relation of trash was not completely eliminated.

A bacterial disease of peas has been collected at the station for more than 3 years. It seems to be increasing in severity. Blotched or girdled stems, spotted leaves, with smooth greasy brown spots, and gnarled circular, sunken spots on the pods are characteristics of this disease. Its importance is as yet unknown, but it bids fair to become as serious as Bean Blight is to the bean crop.

Bean Blight and Bean Anthracnose were important the first half of the season in causing poor stand and seedling injury. As the dry weather came on, Bean Anthracnose largely disappeared and caused but little spotting of the seed beans. Bean Blight on the contrary assumed enormous proportions and caused wholesale injury to the leaves. Seed beans sent in for examination by the laboratory showed an unusually high percentage of yellowed, shrivelled seeds.

Well's Red Kidney beans brought into the state for a test of Anthracnose resistance were in many sections a failure due to the severity of Bean Blight.

A Bean Mosaic which has been seen on plants here and there for several years assumed last year an extremely important role. Whole fields were seen in which not a healthy plant could be found. This was especially noteworthy at one seed farm where a certain wax variety was being increased. Mr. S. P. Doolittle of this department reported in September successful inoculation experiments in which juice from diseased plants was used to convey the disease to healthy plants.

The increasing importance of Mosaic diseases in general, the development of these new and unexpected epidemic troubles, indicates a field of work, worthy of scientific study.

SUGAR BEETS.

A field of sugar beets near Menominee showed nearly 25% loss from Leaf Spot caused by *Cercospora beticola*. One half of the field had been in sugar beets the year before, and the other in grain. One could tell by the excessive amount of Leaf Spot present almost to the row where the beets had stood. Affected plants showed spotted, dry tops and high crowns. Definite, circular areas in which the disease was especially severe could be seen. It was supposed that these areas developed around old piles of tops. No better lesson in the value of rotation could be offered than what was evident in this field.

OAT SMUT.

Dr. Bessey and County Agent H. G. Smith made some counts in fields in Kent County in order to determine percentages of smut in treated and untreated fields.

OAT SMUT IN FIELDS WITH TREATED AND UNTREATED SEED.

Field of:	Treatment.	No. of heads counted.	No. of smutted heads found.	Per cent.	Remarks.
Mr. Harrington (a)	Sprinkled formaldehyde a pt. to 40 gals. water.	1,400 (estimated)	1	......	Same seed used in (b).
Mr. Harrington (b)	Untreated	824	84	10.2	
Mr. Patten (a)	Treated as above	600	2	0.3	
Mr. Patten (b)	Treated as above	10,000 (estimated)	1	......	Swedish select variety (probably).
(Name lost)	Untreated	500	26	5.2	
Mr. Vanecek	Treated in usual manner.	7,800 (estimated)	1	......	Has treated for years.
Mr. Martindale	Treated in usual manner.	18-20,000 (estimated)	11	......	
Mr. Hilton	Did not treat	600	140	23.3	
Mr. Wilson	Did not treat	1,200	83	6.9	Ordinarily treats with a patent compound.
Mr. Bailey	Two tablespoons formaldehyde in 16 qts. water, sprinkled.	660	63	10.5	Evidently too weak. (1 pt. to 64 gals. is rate used)
Mr. Krum	Two tablespoons formaldehyde in 16 qts. water sprinkled (worked in cooperation with Mr. Bailey).	900	28	3.1	
Mr. McPherson	Treated 1 pt. to 30 gal. water, and little more formaldehyde for good measure.	18-20,000 (estimated)	0	0	Has treated for 19 years.
Mr. Bennett	Treated	400	34	8.5	Probably used same method Mr. Bailey.

These figures are fairly representative of conditions in general throughout the state. These figures show the enormous loss which came from failure to treat the grain. Losses as high as 33% are not uncommon in some fields. I have estimated the average annual loss per acre from oat smut at $5.00 for the State in general. This is based on an average loss of 10% of the crop. A questionnaire conducted by Mr. Bentall, County Agent of Allegan County placed the average loss at 8% in his county.

The gain from treatment is also strikingly brought out. Where proper methods were followed the smut was reduced to a negligible amount.

The figures also show the failure which may come from using too weak a solution. Two tablespoonfuls to 16 quarts of water uses formaldehyde at the rate of 1 pint to 64 gallons of water—far below the recommended strength.

The value of treatment year after year is indicated, as well as the necessity of keeping on with the treatment in spite of a long history of previous treatments. Chances of contamination from the few smutted heads which do escape treatment, as well as the infestation which comes from the separator make this necessary.

RYE SMUT.

Observation on Rye Smut (*Urocystis occulta*) was continued again this year by Dr. Bessey. The following table gives a summary of the percentages of infection found:

Location of field.	Date.	Per cent.	Remarks.
Dimondale, Eaton Co.......	June 28, 1916	5-6%	Poor stand due to flooding. Seed not treated.
College Farm, E. Lansing....	July 5, 1916	$\frac{1}{8}$ of 1%	Measured length of rows and estimated number.
South Haven, Van Buren Co.	July 15, 1916	1-5 of 1%	
Big Rapids, Mecosta Co.....	July 17, 1916	Small part of 1%	Three specimens found in a distance of 2,400 feet.
Big Rapids, Mecosta Co	July 17, 1916	0	Adjacent field.

It would seem from these figures that rye smut is not as yet doing great damage in the state, but that it may become serious enough to warrant treatment. Since infection occurs on the sprouting seed from spores outside the grain, seed treatment with formaldehyde as recommended for oats will be successful. It would seem advisable to begin this as a precautionary measure.

THE RELATION OF WEATHER TO EPIDEMICS OF LATE BLIGHT OF POTATO.

BY G. H. COONS.

(Abstract of address given at New York meeting of Botanical Society of America.)

Study of the epidemics of Late Blight of potato in Michigan in 1912 and 1915 has indicated that there is a marked relation between weather conditions in July and the severity of the disease.

The percentage of loss in various parts of the state was determined as accurately as possible by reports from potato buyers, county agents, etc. Comparison of the map made from such data with that showing the rainfall for July shows striking correspondence.

From crop reports and records of the station, it is found that the epidemics of previous years have come in those years when there was more than an average rainfall in July. When such a July is followed

by a month of moderate or heavy rainfall, an epidemic of Late Blight develops.

From a consideration of the rainfall conditions in the first half of the growing season it is possible to predict when spraying is especially necessary—a thing of great importance in view of the high price of Bordeaux mixture and the necessity of economy in its use.

A PHOMA DISEASE OF CELERY.

G. H. COONS.

For several years, growers of celery have complained of a disease of celery characterized by the rotting of the roots, leaving the plant with a conical, rotted base. Such plants turn yellow and topple over in the row. The disease has probably been referred to before in the literature, for numerous accounts have appeared in which the same pathological picture is described. The fungus Rhizoctonia has been suspected as the etiological factor.

On rotted plants, the fruiting bodies of a Phoma were discovered. This fungus was obtained in pure culture and typical lesions were obtained in inoculation experiments. The etiological relation of the Phoma thus obtained has been fully established. The fungus in culture and pathological habit greatly resembles *Phoma apiicola* described by Klebahn as producing the "Scab" of Celeriac.

The fungus has been found to persist in greenhouses year after year, the disease appearing in the field only in the plants from houses known to be infested. In such cases plants in adjoining fields might be entirely free from the disease. The fungus shows marked susceptibility to high temperatures. Cultures made in mid-summer failed to grow. In this connection it is noteworthy that attack in the field is restricted to the first crop of celery which is set out in early spring. The second crop in rows adjacent to those showing complete failure frequently escapes the disease entirely.

REPORT OF THE CHEMIST.

Director R. S. Shaw, East Lansing, Michigan.

Dear Sir:—I herewith submit a brief report of the work of the Chemical division for the year ending June 30, 1917.

Two changes in the personnel of the staff occurred during the year. Mr. A. E. Smoll resigned early in April to accept a position as chemist with the Jacob Dold Packing Company, Wichita, Kansas, and Mr. E. A. De Windt resigned June 1st to enter upon a business career. Both of these young men rendered valuable service to the institution. The vacancies will be filled by Percy O'Meara, of the class of 1917, and T. E. Friedemann who for the past two years has been an instructor in chem-

istry in the College department. These appointments are effective September 1st. Mr. George Wible was employed early in April as a temporary assistant during the fertilizer season.

CONTROL WORK.

Fertilizer Inspection: Bulletin 278 giving the results of 549 samples of fertilizer analyzed during the season of 1916 was published early in the year. Owing to the increased cost of fertilizers this year and the evident increase in the amounts used, the annual spring inspection was prosecuted with more vigor than ever before. About 700 samples have been secured. The results of 518 samples already analyzed have been summarized for publication in circular form in advance of the fall season.

FEEDING STUFFS INSPECTION.

The first feeding stuffs bulletin, No. 276, was published in November, 1916, giving results on more than 800 samples. A smaller number of samples were collected this year owing to the scarcity of feed stuffs on the market. The analytical work has been finished and the results will soon be ready for publication. It is interesting to note that the number of samples falling below guarantee this year is considerably less than the number found last year.

During the last session of the Legislature a new feeding stuffs bill was introduced and passed. This bill is copied after the proposed uniform law drafted by the Association of Feed Control Officials of the United States. The law will not become operative until April 1st, 1918. It will give us far better control over the feeding stuffs sold in the State than under the old law. One of the requirements under the new law is the declaration of the ingredients used in compounding mixed feeds. This will require a microscopical examination of all mixed feeds in the future. We have given some attention to this phase of the subject during the past year but as proficiency along this line comes only with years of experience, the extent of our examination was more or less limited.

I would recommend that Mr. Berger be allowed to spend two or three weeks at some other institution where this work has been in progress for several years in order to become familiar with the methods used and learn something of the technique.

INSECTICIDE INSPECTION.

Special attention has been given during the year to preparations intended for treating wheat and other small grains for the prevention of smut. In every case these were found to contain formaldehyde as the active ingredient to which had been added some coloring matter and usually a small amount of carbolic acid and lye. These preparations were being sold in violation of the law in that no statement appeared on the labels as to the active and inactive ingredients. The retail price of the mixtures ranged from $1.25 to $2.00 per pint or from five to eight times the cost of formaldehyde. All of the manufacturing concerns resident in Michigan were notified of the law and it is gratifying to report that steps were immediately taken by all of them to comply with the requirements.

HATCH FUND.

Further work has been carried on during the year in a study of the manufacture of concrete drain tile. The object sought is a tile which will not allow water to percolate through the walls. It has been found that this condition can be obtained very satisfactorily when the sand and gravel are graded according to Fuller's curve. Still better results are obtained when the sand and gravel are graded according to Fuller's curve and 10 per cent of cylinder oil is added to the water before mixing the concrete. Tile made in this way and then properly cured are practically impervious. This work will be ready for publication soon.

Work has been done during the year on the composition of and methods for analyzing lime-sulphur solutions. This work is still in progress and no conclusions are yet available.

A short paper giving the details of a method for estimating calcium and strontium in the presence of phosphoric acid and small amount of iron was published in the Journal of Industrial and Engineering Chemistry.

All of the work under this fund has been done by Mr. Winter.

ADAMS FUND.

Leave of absence for one year was granted to Mr. Robinson at the beginning of the year for advanced study at the University of Michigan where he received the degree of Ph. D. at the recent commencement exercises. Mr. Robinson has directed the work under this fund during the year and the following report is submitted by him:

"The manuscript of the bulletin dealing with the work done by Dr. J. E. Harris under Project 2b, 'Adsorption in relation to soluble fertilizer salts,' has finally been completed. An article describing this work will also appear shortly in one of the chemical journals.

"The investigation under Project 2ba, 'The organic nitrogenous compounds in peat soils,' have been continued along the lines previously laid out. The study of the various forms of nitrogen in peat soils has yielded positive results and more work has been done on the application of the methods of analysis perfected in this work to the analysis of other organic materials used in the manufacture of fertilizers.

"The study of the effect of liming peat and muck soils, mentioned in the last report, has been continued and some interesting results have been obtained.

"The preliminary experiments on the first problem taken up under Project 2e, 'Adsorption in relation to osmosis in soils' have been completed and a manuscript describing them is ready for publication. Work on the second stage of the problem is progressing favorably and nearly enough data for a second publication are available."

MISCELLANEOUS.

One hundred and ninety-five samples of a miscellaneous nature were analyzed during the year, and in addition, a large number of marl and limestone samples have been examined as to their value for applying to acid soils.

Mr. Winter was appointed referee on insecticides for the Association of Official Agricultural Chemists and other members of the staff have collaborated on methods of analysis along other lines.

A four week's course of lectures on Fertilizers was given by the writer to the short course students in General Agriculture.

Respectfully submitted,
ANDREW J. PATTEN,
Chemist.

East Lansing, Mich., June 30, 1917.

REPORT OF THE ENTOMOLOGIST.

Director R. S. Shaw:

Dear Sir—Following is a brief report of the work of the Division of Entomology for the year ending June 30, 1917.

The year just passed has brought to us more than the ordinary number of problems, the season of 1917 opening with rains and cold weather, continuing up to the present moment almost without intermission. These conditions have been favorable to a number of insect pests, which have succeeded in doing quite a bit of damage.

Plant lice have been plentiful on almost everything, fruits of all kinds suffering in consequence. Root maggots have levied far more than their ordinary toll, the onion maggot and cabbage maggot making much trouble early in the season, and the bean maggot causing very heavy losses, and continuing their work up to the present moment. The Closer Leaf Beetle was present in some districts early in the season, and a snout beetle on alfalfa is becoming common in the state, even destroying entire fields in some regions. This snout beetle, *Sitones hispidulus,* while it has been noted in the state before, is working on all the clovers, and is gaining in numbers rapidly. The Fruit Tree Leaf Roller has continued to thrive in restricted areas, and has proven very difficult to control. A borer in young corn plants, resembling the Tomato Stalk Borer, if, indeed, it does not prove to be the same thing, has appeared in some fields and destroyed the young corn plants wholesale. The Tomato Stalk Borer, *Papaipema nitela,* is at present ravaging the potato fields, tunnelling in the stems of the plants and killing many outright.

The test on the comparative values of various insulators to be used in double-walled bee hives was temporarily discontinued during the present season, owing to a change in the personnel of the department. It will, however, be taken up during the coming winter, and we hope, completed.

The investigation of the new peach difficulty in the western part of the state, has been diligently pursued during the present year, and much progress has been made. We feel quite confident of the successful outcome of this investigation. The difficulty is due to an insect that produces blemishes on peaches—especially on Elbertas. These blemishes do not injure the fruit very much for consumption, but fruit which would otherwise be classed as fancy, has to be disposed of almost as culls.

The investigation of a pest causing Witch's Broom in gooseberry, has been carried on, and the prospect of a successful outcome of the work is very promising. A series of experiments has been instituted looking to

the control of Woolly Louse in young apple trees in the nursery. This question is one of prime importance, but we do not hope for immediate results, since the question is an old one, and one that has occupied the attention, both of entomologists and nurserymen for many years. We do not despair, however, of finally discovering some method that will make it possible for the nursery to send out really clean stock without discarding an unreasonable percentage of their young trees. This latter experiment is in cooperation with one of the largest nurseries in the state.

During the year Mr. G. C. Woodin resigned, in order to pursue graduate work elsewhere. Mr. Woodin left on the 1st of September, 1916. His place has been filled by Mr. P. B. Wiltberger, who took up his duties on the 1st of April, 1917. Mr. Wiltberger, is, at present, doing considerable field work in the control of the insect enemies of fruits and field crops, and is employed by the Station for half of his time. I regret to have to report that Doctor G. D. Shafer, Assistant Professor in the College and Associate Entomologist of the Station, leaves us on the 1st of September next. Doctor Shafer intends to take up private work in the west, at least for a time. No one has as yet been appointed to fill his position, which deals almost exclusively with investigations of basic problems.

During the year many insects have been reared, and records made of importance to the agriculturist, and one bulletin has been prepared by Doctor Shafer, the title of which is "A Study of the Factors which Govern Mating in the Honey Bee." This bulletin is, at present, awaiting the action of the Experiment Station Council. Another bulletin, dealing with the classification of the Orthoptera of Michigan, is well under way, and we expect to present this very shortly. A number of press bulletins have been prepared, dealing with various insect enemies as they have appeared.

Respectfully submitted,
R. H. PETTIT,
Entomologist of Experiment Station.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DIVISION OF HORTICULTURE.

To the Director:

Sir—I herewith make a report of the Division of Horticulture for the year ending June 30th, 1917.

During the past year special attention was paid to the following experiments which are here briefly referred to:

The dusting and spraying experiments in apple orchards were conducted on a commercial scale at Morrice and Grand Ledge. The idea was to make a comparative test of the value of these different ways of protecting apples from the ordinary diseases and insects and also the economics of the different methods. The sprayed portions of the orchard contained a much greater percentage of good fruit than those parts that had been dusted. While it is true that the dust can be applied much more rapidly than the liquid, the cost of the material for the dusting was

nearly four times as great as the liquid. It may be that future tests will show that a greater number of dustings must be made than spraying and whether with the great difficulty in securing labor, it will not be more economical even if there is a somewhat larger percentage of scabby fruit.

A test has been started to determine the comparative value of the self-boiled lime-sulphur as a protection from the ordinary peach diseases, and the dusting. This is being made at Bangor.

Experiments in spraying raspberries to protect them against the common disease known as Anthracnose, that have been carried on at Eaton Rapids in 1914 and 1915, are now being made at Leslie and at this time, favorable results are apparent from the use of commercial lime-sulphur, one part to 20 parts of water, made when the bushes are dormant.

Comparative tests of several commercial preparations for the spraying of apple orchards were used, together with home-made standard preparations and the commercial lime-sulphur and arsenate of lead. None of these patented commercial materials were as satisfactory as the home-made materials or the ordinary commercial lime-sulphur. Many of them were ineffective, caused injury to fruit or foliage and were hard and disagreeable to prepare.

Potato spraying experiments were continued but since the crop was exceedingly small, no definite or reliable results were secured.

An experiment in the spraying of grapes was carried out at Paw Paw. The idea was to try and determine if something cheaper and as satisfactory as copper sulphate could be used. Owing to the very high price of the copper sulphate in 1916, this was desirable. The tests included Bordeaux mixture at various strengths, ammoniacal copper carbonate and several patented compounds and also a number of different sprays. The results show decidedly that the Bordeaux mixture sprays were the best and the one made with 4 pounds of copper sulphate, 4 pounds of lime to 50 gallons of water and applied four times was the best of all.

The experiments to determine the value of preserving fruits and vegetables by freezing at a low temperature have shown that it is possible to hold several kinds of fruit in good condition. Nearly all of the smaller fruits, such as cherries, currants, gooseberries and raspberries, have been preserved very well. Strawberries which had been frozen were not desirable. The quality of sweet corn after freezing was not very good. The corn was rather watery and not very sweet. Frozen asparagus when cooked was dark, tough and strong. Cooking tests were made by Professor Mary Edmonds of the Domestic Science department. Experiments were carried on in 1915 and 1916 to determine how long freshly cut asparagus can be held in temperatures above 32 degrees Fahrenheit. It was kept in good condition for two or three weeks when set in water. The most desirable temperature is probably a few degrees above freezing, 35 to 38 degrees.

A patented peach tree borer protector that fitted around the base of the peach tree with the idea of making it impossible for the borers to work into the trunk of the tree was tested out in the peach orchard at Morrice. They were placed on the trees in June, 1916. They have kept the trees free from the borers where the cemented joints of the protectors were not broken open by the growth of the trees but about one-third of them have been broken open in this way. There was practically

no difference in the amount of borers where this protector had been used in this way and where the trees were not protected at all.

It was desired to determine what length of time asparagus would remain in wholesome condition when placed in commercial cold storage. There may be a few excessively warm days in the spring when growers would harvest large quantities of asparagus. These days might be followed by a period of low temperatures and growth practically ceased. Could the asparagus be temporarily placed in cold storage and retain its fresh qualities and for how long? Experiments were started in 1915 and continued in 1916.

Two methods were used: (1) The bunches were simply packed in paper lined boxes or baskets and (2) the bunches were set in shallow water in pans. In 1915, asparagus was stored over the ice in an ice house and in an egg room at the Lansing Cold Storage. In 1916 it was stored in the egg room only. The temperature in the ice house ranged from 34 to 38 degrees Fahrenheit and in the egg room was lower, 32 to 33 degrees. Record was made of the weight and length of bunch when placed in storage and at intervals after that.

In 1915, the bunches in the egg room which were set in water averaged 6.6 ounces in weight and 7.5 inches in length. There was an increase in weight of 0.2 ounces in a period of 10 days. There was no appreciable change in length. That stored in water lost 0.7 ounce in weight without any change in length. When not in water, the stalks had wilted and were slightly shriveled while that set in water was firm and bright and in good condition. The bunches in baskets in the ice house showed no loss in length or weight, but the stalks were slightly wilted. The bunches set in water averaged 7.4 ounces in weight and 7 inches in length. There was an increase in weight of 1.3 ounce and 0.2 inch in length in a period of 12 days. The condition was very good; in fact, no difference could be noticed between it and freshly cut stalks. Some of this along with freshly cut asparagus, was sent to the Domestic Science department to be cooked. That which had been stored in water was found to be as desirable as the freshly cut.

In 1916, the experiment was continued over a longer period to see how long the asparagus would remain in good condition. It was found that after two or three weeks, the stalks wilt and later soften. This is evident first in the tips, then it develops downward. Any temperature lower than 32 degrees F. will cause asparagus to become dark and soften.

The results from this work indicate that asparagus can be held in good condition for at least two weeks if set in water. The most desirable temperature is probably 36 to 38 degrees or possibly a little higher. At this temperature there is no change of any consequence in either weight or length.

Extensive experiments in cross breeding are under way at the Sub-station at South Haven. All of this work is done in full cooperation with the Bureau of Plant Industry of the Department of Agriculture and includes crosses of all of the tree fruits, grapes, and some of the small fruits.

Other experiments are under way but at the present time are not far enough developed to draw any conclusions. These are on the farms of the following parties:

George Winegar & Son, Morrice,
J. E. Merritt, Manistee,
C. H. Whittum, Eaton Rapids,
T. A. Farrand, Eaton Rapids,
B. F. Hall, Belding,
L. E. Hall, Ionia,
C. W. Garlock, Grand Ledge,
John Strange, Grand Ledge,
Oscar Braman, Grand Rapids,
L. A. Bregger, Bangor,
E. W. Potter, Leslie,
Joseph Sill, Onaway.

Respectfully submitted,
H. J. EUSTACE,
Horticulturist.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DIVISION OF FARM CROPS.

Director R. S. Shaw, East Lansing, Mich.:

Dear Sir—I have the honor to submit the following report for the Division of Farm Crops for the year ending June 30, 1917.

The resignation of Professor V. M. Shoesmith was accepted by the State Board of Agriculture, and went into effect April 1st. Before taking leave, Professor Shoesmith completed a report of the fertilizer and rotation experiments which have now progressed for six years. The greater part of the data included in his report is here given. In general, the results obtained from this extensive project increase in value year by year, and work will be continued under the direction of the department staff. It was decided that certain plats have run their course, and that continuation is no longer advisable. These have been discontinued and the land used for other purposes. In the main, however, the project will be continued as originally planned.

Experiments with the rate and method of planting beans, the effect of field selection of beans on yield and disease resistance, and experiments with various varieties of soy beans for silage purposes, are under way. A project, aiming to determine the effect of various companion crops on seedings of clover and alfalfa, and the effect of time of seeding, and subsequent handling of same, is also being carried out.

The variety test work with corn on the Station farm is being continued under the direct supervision of Eugene E. Down. Work of a similar character has been extended to a number of communities widely scattered over the state. Twenty-six variety tests of corn, including local varieties and the best varieties of possible worth obtainable, have been put out at widely distributed points. It is thought that these variety tests will do much toward determining the varieties best suited to the section in which they are conducted.

Further details of the work of the division are embodied in the report of F. A. Spragg, Plant Breeder.

Respectfully yours,
J. F. COX,
Acting Head, Division of Farm Crops.

East Lansing, Mich., June 30, 1917.

PLANT BREEDING.

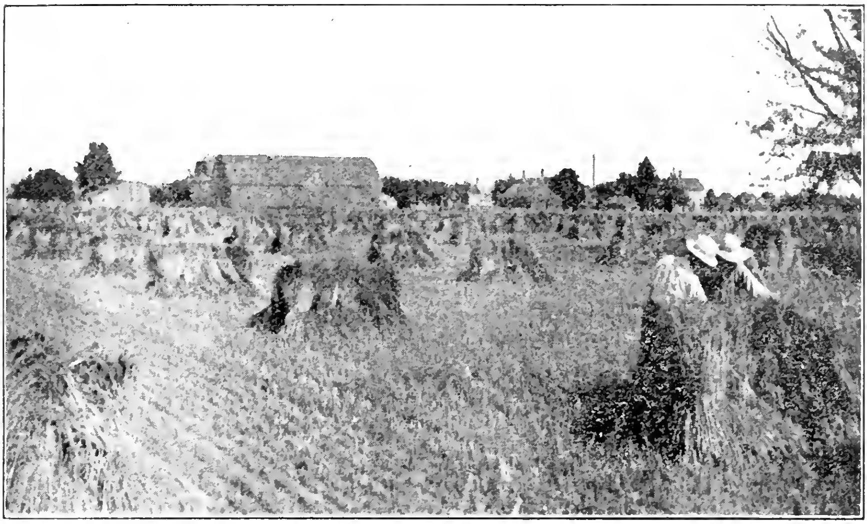
Professor J. F. Cox, East Lansing, Michigan:

Dear Mr. Cox—The work in Plant Breeding in my charge during the past ten years may be summed up briefly in the form of results.

A view of Field No. 8 in 1912 showing yield of 75 bushels per acre of Worthy oats.

Figure 1 shows a view of a field of Worthy oats giving a yield of 75 bushels per acre in 1912. This oat is yielding at least ten bushels per acre above common. There are about 50,000 acres of these oats now growing in Michigan. At $.60 per bushel, these oats will give Michigan approximately $300,000 in 1917 over what it would have received without it.

Figure 2 shows a portion of the three hundred acres of inspected Red Rock wheat now growing in Allegan county. In the state of Michigan in 1917 there are approximately 4,000 acres of this new grain which is yielding from five to ten bushels above common wheats. At $2.50 per bushel, considering a gain of only five bushels per acre, this new wheat



View of Red Rock Field.

A Field of Rosen Rye.

will yield Michigan in 1917 an increased income of $50,000 without plowing or harvesting another acre.

Figure 3 shows a field of Rosen rye, a crop that is producing twice as much grain as the old time common rye. In Jackson and eastern Calhoun counties there are approximately 500 acres of this grain per township, averaging about thirty bushels per acre with much of it yielding much above this. There must be at least 15,000 acres of this grain in 1917 producing about 200,000 bushels above what would have been produced by the old time common rye on the same acreage. At $2 per bushel this is a saving of $100,000 for Michigan in 1917.

The Worthy oats, Red Rock wheat and Rosen rye are only examples of what this work is doing and is capable of doing. The figures are for 1917 valued at market price.

If only a quarter of this grain be used for seed for 1918, the added income would be somewhat as follows:

Worthy oats would plant....	250,000 acres and save	$1,500,000
Red Rock wheat would plant	16,000 acres and save	160,000
Rosen rye would plant......	160,000 acres and save	4,000,000

The policy has been to introduce the best at the time of introduction, and then to introduce a better variety when it can be produced, tested and increased. Thus, the Shepherd's Perfection wheat was introduced about three years ahead of the Red Rock. In several districts which the writer has recently visited, the Shepherd's Perfection constitutes fifty to seventy-five per cent of all the wheat being grown for a distance of at least five miles in any direction from the point of introduction.

The spread of these new grains is contagious.

Respectfully submitted,

F. A. SPRAGG,
Plant Breeder.

East Lansing, Mich., June 30, 1917.

ROTATION, MANURE AND FERTILIZER EXPERIMENTS.

BY PROF. V. M. SHOESMITH.

These experiments are located in Field 9 of the College farm which is the second field south of the river on the east side of the farm lane. The soil is a miami sandy loam to a clay loam, with a few clay spots which have a comparatively low organic content. The previous cropping of this field was the same as for other fields of the farm, viz., a rotation of corn, oats, clover, hay and pasture. A fairly liberal application of manure, ten to twelve tons per acre, has been made once during the rotation at least on the higher portions of the field, and usually most of the field has been covered. No commercial fertilizer or lime so far as known has ever been applied to this field previous to the inauguration of this experiment. The field was in a fairly productive condition at the beginning of the experiment.

A portion of the field was tile drained previous to the beginning of the experiment, which, with the natural drainage was considered to pro-

vide sufficient drainage. However, some of the plats were found to be poorly drained, especially during the wet spring of 1912 and an additional system of tile drainage was put in in the fall of 1912. Additional drainage is still required for a few of the plats in the 200 series.

Each plat is 31½ feet by 138.3 and contains one-tenth of an acre, adjacent plats being separated by alleys three and one-half feet wide.

It should be noted that in the fertilizer plate Series I, in which the fertilizer is applied to a corn, wheat, clover rotation, the plats are triplicated (in the same series) so that each crop of the rotation is grown each year. Likewise that the rotation and manure experiments in Series II are triplicated in Series III and IV for the same purpose.

During the spring of 1912, or the second year of the experiment, the north half of all of the plats in Series I and II were treated with ground limestone at the rate of two tons per acre. It was the plan at the time to apply lime to all the plats later if it was found beneficial. However, in 1912, 1913 and 1914 very little if any difference could be observed in the growth of the clover on the limed and unlimed portions of the plats. In putting in the tile drains in the fall of 1912, lime-bearing subsoil was found so that conclusion was reached that a general application of lime was not essential at that time. In 1915 there was no apparent difference between the limed and unlimed portions of the check plats but on all the fertilizer plats the limed portions produced an appreciably larger growth of clover with less grass and weeds than the unlimed portion.

In 1916 the effect of the lime applied to Series I was much more noticeable than previously and could be readily observed on most of the clover plats. The plats to which fertilizers were applied, however, showed a much more marked effect from the lime than the unfertilized plats, the unlimed portions containing more June grass, red top, sorrel and other weeds, and more alsike clover and less red clover, as well as a smaller total yield as compared with the limed portion.

In the fall of 1916 carbonate of lime secured from I. E. DuPont De Nemours Company of Bay City was applied in a very dry condition at the rate of three tons per acre on all the plats in Series I, II and III. (It is planned to lime Series IV during 1917). A chemical analysis made of several samples taken late in the fall after the application had been made, indicated a slight acidity still, but it may be that this will not be true after lime has been more thoroughly incorporated into the soil.

The cultural conditions have on the whole been as favorable as could well be provided. Early maturing varieties of corn and the pedigreed varieties of small grain developed by the Experiment Station have been used. The yields of small grain have been very satisfactory, in fact all that could be expected. The yields of clover have been medium to good but somewhat spotted. The corn yields on many of the plats have been rather low, the corn making a slow growth throughout the season and maturing poorly doubtless on account of the rather unproductive condition of this field and the fact that no manure has been applied during the rotation.

FERTILIZER EXPERIMENT.

In this experiment the fertilizer is applied to wheat in a corn, wheat, clover rotation. All the fertilizer has been applied in the fall at the time of seeding with the exception that one-half the nitrate has been applied

in the spring. The yields of wheat, clover and corn value of increase, cost of treatment and net value of increase per rotation are given in Tables I and II. The clover yields for 1911 and the corn yields for 1911 and 1912 are not included because the treatment had not been made and the clover yields for 1912 are not included because of irregularity of growth due to soil variations.

TABLE I.—RESULTS OF APPLICATION OF FERTILIZER TO WHEAT IN CORN, WHEAT, CLOVER ROTATION, 1911-1915.

Treatment per acre.	Average yield wheat (3 crops) after fertilized.	Average yield clover (3 crops) after fertilized wheat.	Average yield corn (3 crops) second year after fertilized wheat.	Value of increase per rotation.	Cost of treatment.	Net value of increase per rotation.
No fertilizer	21.38	1.61	38.8	....	....	....
75 lbs. nitrate of soda 200 lbs. acid phosphate 75 lbs. muriate of potash	34.28	2.03	43.7	19.24	5.73	13.51
75 lbs. nitrate of soda 200 lbs. acid phosphate	29.96	1.95	40.1	12.03	3.85	8.18
200 lbs. acid phosphate 75 lbs. muriate of potash	31.68	2.03	42.8	16.27	3.48	12.79
200 lbs. acid phosphate	27.68	1.98	40.0	10.21	1.60	8.61
100 lbs. acid phosphate 100 lbs. floats	25.56	1.83	40.0	6.80	1.25	4.55
200 lbs floats	25.06	1.88	40.0	6.85	.90	5.95

In compiling these data none of the yields of individual plats were assumed to be in excess of those from other plats receiving the same and additional fertilizer ingredients.

TABLE II.—YIELDS PER ACRE OF CORN, SECOND YEAR AFTER FERTILIZED WHEAT, IN A CORN, WHEAT AND CLOVER ROTATION, 1913-1916.

Treatment per acre.	1913.	1914.	1915.	1916.	Average for 4 years.
No fertilizer	47.0	32.8	36.8	23.3	35.0
75 lbs. nitrate of soda 200 lbs. acid phosphate 75 lbs. muriate of potash	56.2	40.1	43.7	34.3	43.6
75 lbs. nitrate of soda 200 lbs. acid phosphate	44.5	33.2	42.1	30.5	37.6
200 lbs. acid phosphate 75 lbs. muriate of potash	56.2	37.3	43.7	32.5	42.4
200 lbs. acid phosphate	46.5	33.2	42.1	28.2	37.5
200 lbs. floats	44.5	34.8	38.5	25.0	35.7

The use of the fertilizer has resulted in a much larger increase in the case of the wheat than either the corn or clover. However, the residual effect of the fertilizer is very noticeable in the latter two crops.

It will be noticed from a study of Table I that the highest value of increase per rotation was secured from the use of the complete fertilizer, the second highest from the acid phosphate and muriate of potash, third from the nitrate of soda and acid phosphate, fourth from the acid phosphate and the least from the floats. The net value of the increase, i. e., the profit after paying for the fertilizer, takes the same rank as above though the net returns from the complete fertilizer are not greatly in

excess of the acid phosphate and muriate of potash and the nitrate of soda and acid phosphate has proved but little better than the acid phosphate alone. On lands liberally treated with barnyard manure these differences would probably be smaller or would disappear altogether. The floats or raw phosphate rock, though costing only a little over one-half as much as the acid phosphate and carrying approximately twice as much phosphoric acid has given only about half as good net returns.

It should be noted that all the fertilizers have been used with good profits. The conclusion would seem to be warranted that on farms of similar soil types the use of proper fertilizers should prove profitable, provided, of course, there are no other factors such as lack of drainage, proper culture, etc., that seriously limit production, and that the use of a complete fertilizer should pay best in case a limited amount of manure is available, while on well stocked farm the phosphorus and potash would probably be used most profitably.

MANURE EXPERIMENTS.

In the manure experiments the manure has been taken from the cow stable and placed in a pile which has been forked over several times so as to mix it thoroughly and make it as uniform as possible. Later it has been divided and certain lots treated as per plan, the treatment usually being made four to six weeks previous to applying to the field. The yard manure has been placed in a large open box outside while all the other lots have been preserved under cover. The manure has been applied to the corn crop in a corn, wheat, clover rotation two to four weeks previous to plowing.

The yields of corn and clover from the several treatments are given in Tables 3 and 4.

TABLE III.—YIELDS PER ACRE OF MANURED CORN IN A CORN, WHEAT AND CLOVER ROTATION, 1911-1916.

Treatment per acre.	1911.	1912.	1913.	1914.	1915.	1916.	Average for 6 years.
No manure or fertilizer	38.5	41.3	46.8	20.3	32.0	20.0	33.2
5 tons yard manure	45.7	46.3	51.0	38.1	40.9	26.1	42.4
5 tons stall manure	45.7	46.3	56.6	38.1	43.0	26.2	42.7
5 tons stall manure, 200 lbs. acid phosphate	57.0	48.4	60.8	46.7	47.4	32.0	48.7
5 tons stall manure, 200 lbs. floats	51.0	49.3	57.2	48.2	43.0	28.4	46.2
10 tons stall manure	52.0	48.5	65.7	51.6	48.8	28.7	49.2

TABLE IV.—YIELDS PER ACRE OF CLOVER, SECOND YEAR AFTER MANURED. CORN IN CORN, WHEAT, CLOVER ROTATION, 1915-1916.

Treatment per acre.	1915.	1916.	Average.
No manure	1.22	1.78	1.50
5 tons yard	1.67	2.45	2.06
5 tons stall	1.67	2.45	2.06
5 tons stall and acid phosphate	2.06	2.63	2.35
5 tons stall and floats	1.18	2.50	2.16
10 tons stall	1.91	2.82	2.37

All of the manured plats have produced much better yields of all the crops of the rotation than have the plats receiving no manure, the increase in the wheat and clover yields being as great, in fact somewhat greater than those of the corn to which the manure was applied. The residual effect of the manure, as would be expected, is greater than of the commercial fertilizer applied in Series I.

Attention is called to the relatively high values placed upon the manures, viz., $3.25 and $3.81 per ton for the yard and stall manure, respectively, when applied at the rate of five tons per acre, and $3.43 per ton for the stall manure when applied at the rate of ten tons per acre.

These figures should not be accepted as representing manurial values under all conditions. On soils abundantly supplied with organic matter and available plant food or with heavy applications, the price per ton would be less than these figures would indicate. These data, however, show the value of manure under conditions prevailing in this experiment and indicate clearly the relatively high values that should be placed generally on live stock manures, and should encourage farmers to inaugurate systems of management which will stop the excessive waste of manurial elements which takes place on most farms today.

Although the manure used alone has given such splendid returns the manure which has been reinforced by acid phosphate at the rate of two hundred pounds per acre has given approximately twice as large returns, i. e., the manure re-inforced with acid phosphate has produced a sufficient increase to place a value of $7.00 per ton on the manure after paying for the acid phosphate. The manure, of course, carries only a small amount of phosphorus and evidently the lack of phosphorus is to a very large extent a limiting factor on this land (as it is more or less generally about the state) so that the use of phosphorus with the manure is much more profitable than the use of the manure alone.

The use of floats or raw phosphate rock is sometimes recommended as a carrier of phosphorus, especially when applied with manure or plowed under with a green manure crop. In this experiment the manure which has been re-inforced with the floats at the rate of two hundred pounds per acre, has made somewhat better returns than the untreated manure, but not nearly as good as the manure which has been reinforced with acid phosphate, the net value of the manure treated with floats being $4.68 as compared with $3.81 in the untreated manure and $7.00 for the manure treated with acid phosphate. When it is desired to use the carrier of phosphorus as an absorbent in the stable it may be that the cheaper material (floats) would prove the more satisfactory but even under these conditions it probably would be better to use a still cheaper absorbent, such as muck or peat, and use the acid phosphate to supply the phosphorus.

ROTATION OF CROPS AND CONTINUOUS CROPPING EXPERIMENTS.

This experiment includes a number of three year rotations and several plats devoted to the growing of the same crops continuously. The object in the rotation experiment is to determine the effect of growing one crop after another and the relative profit from the different crops and from the different rotations. The clover is introduced in nearly all these rotations as an aid in maintaining the fertility of the soil and so that this experiment may represent as nearly as possible actual farm

conditions. The number of crops in the rotations has been limited to three so as to limit the variable factors so far as possible.

In the corn, beans and clover; corn, beets and clover; and beets, corn and clover rotations the seedings of clover have not as a rule been successful and soy beans have been used as a substitute for the clover.

The growing of the same crops continuously has been introduced in the experiment for the purpose of securing experimental data and as a demonstration in continuous cropping in comparison with the rotation of crops rather than as a desirable farm practice.

The annual yields of the various crops are given in Table 5 and in Table 6 are presented the average yields and the total value of crops per rotation.

TABLE V.—YIELDS PER ACRE OF CROPS GROWN IN ROTATION AND GROWN CONTINUOUSLY. (GRAIN IN BUSHELS; HAY AND BEETS IN TONS.)

	1911.	1912.	1913.	1914.	1915.	1916.	Av.
Corn, oats, clover:							
Corn	34.1	50.9	43.4	36.0	19.6	22.2	34.4
Oats	28.1	44.8	23.7	43.5	73.5	50.4	44.0
Clover	....	....	1.76	....	.91	1.18	1.28
Corn, rye, clover:							
Corn	29.7	45.3	49.2	37.3	34.0	22.5	36.3
Rye	29.0	35.9	28.9	17.2	27.7	37.2	29.3
Clover	....	....	18.3	1.41	1.32	1.58	1.53
Corn, wheat, clover:							
Corn	38.5	45.3	46.8	33.4	32.0	20.0	36.0
Wheat	36.4	21.8	20.7	21.0	22.7	14.7	23.4
Clover	....	....	1.46	1.63	1.22	1.78	1.52
Corn, wheat, timothy:							
Corn	34.2	43.1	38.9	29.8	34.0	20.6	33.4
Wheat	44.2	15.7	16.8	16.0	16.7	13.0	20.4
Clover	....	....	.90	1.68	1.38	1.85	1.45
Beans, wheat, clover:							
Beans	12.3	20.3	22.5	22.8	6.7	....	14.1
Wheat	36.0	24.4	17.2	24.9	32.2	18.2	25.5
Clover	....	....	1.37	1.50	1.09	1.72	1.42
Beans, oats, clover:							
Beans	10.9	19.0	20.8	15.7	1.8	....	11.4
Oats	44.1	33.3	28.7	38.2	66.1	31.0	40.2
Clover	....	....	.95	....	1.92	1.89	1.59
Potatoes, wheat, clover:							
Potatoes	65.7	46.5	194.5	172.7	60.0	14.8	92.4
Wheat	39.3	31.3	29.2	27.1	26.9	17.1	28.5
Clover	....	....	1.89	1.47	1.63	2.09	1.59
Potatoes, rye, clover:							
Potatoes	62.5	117.2	154.5	174.0	53.3	14.8	96.5
Rye	30.3	43.0	32.5	20.0	24.7	33.1	30.6
Clover	....	....	2.13	1.55	1.53	2.13	1.88
Beets, Corn, Clover, Soy Beans:							
Beets	47.9	32.8	44.4	40.6	31.1	8.4	34.2
Corn (beets)	5.05	4.85	....	4.88	4.63	7.48	4.48
Clover	....	....	....	....	.50	1.76	1.13
Corn, beets, clover:							
Corn	42.0	52.6	50.2	47.4	30.9	14.3	39.6
Beets	6.43	5.40	....	2.40	7.38	6.17	4.63
Clover	....	....	....	20.70	8.67	6.50	11.96
Beets, oats, clover:							
Beets	10.40	6.11	....	4.75	5.39	6.99	5.61
Oats	34.1	45.3	27.4	30.8	72.2	26.0	39.3
Clover	....	....	2.32	14.8	1.70	2.04	2.02

TABLE VI.—AVERAGE YIELD PER ACRE AND VALUE OF CROPS GROWN IN ROTATION AND GROWN CONTINUOUSLY.

Rotations and average crop yields per acre.			Total value of crops per rotation.
Corn....... 34.4 bu.	Oats...... 44.0 bu.	Clover............ 1.28 tons......	$50 56
Corn....... 36.3 bu.	Rye...... 29.3 bu.	Clover............ 1.53 tons......	59 41
Corn....... 36.0 bu.	Wheat.... 23.4 bu.	Clover............ 1.52 tons......	59 66
Corn....... 33.4 bu.	Wheat.... 20.4 bu.	Timothy.......... 1.45 tons......	54 57
Beans...... 14.1 bu.	Wheat.... 25.5 bu.	Clover............ 1.42 tons......	61 12
Beans...... 11.4 bu.	Oats...... 40.2 bu.	Clover............ 1.59 tons......	49 35
Corn....... 30.8 bu.	Beans..... 10.0 bu.	Clover, soy beans... 9.13	....
Potatoes.... 96.5 bu.	Rye...... 30.6 bu.	Clover............ 1.88 tons......	83 65
Potatoes.... 92.4 bu.	Wheat.... 28.5 bu.	Clover............ 1.59 tons......	83 13
Beets....... 5.61 tons	Oats...... 39.3 bu.	Clover............ 2.02 tons......	62 00
Beets....... 4.48 tons	Corn...... 34.2 bu.	Clover, soy beans... 1.13...........	55 93
Corn....... 39.6	Beets..... 4.63	Clover, soy beans...11.96...........	69 98
Wheat, continuously..............	19.7 bu............		53 19
Corn, continuously................	28.5............		18 40
Beans, continuously...............	9.1............		46 41
Beets, continuously...............	4.89............		73 35
Potatoes, continuously.............	80.2............		108 27
Timothy, continuously.............	1.23............		36 90
Alfalfa, continuously..............	2.13............		63 90

The value of the above crops are based on the following prices: Corn, 65c; oats, 35c; wheat, 90c; rye, 70c; beans, $1.70; soy beans, $2.25; potatoes, 45c per bu.; hay $10.00 and beets, $5.00 per ton.

In the rotation of corn, small grains and clover, better crops of corn and better crops of clover have been secured in the wheat and rye rotations as compared with the oat rotation. The yield of wheat in pounds is about equal to the yield of oats but the yield of rye in pounds is about sixteen percent higher than the oats. The value of the wheat and rye crops are both about 34 per cent in excess of the value of the oat crop which would indicate that on land of this type the wheat and rye are at least better cash crops than oats.

The yields of timothy in the corn, wheat, timothy plat have been nearly as large as the clover in the corn, wheat, clover rotation but the yield of corn has been seven percent lower and the wheat fourteen percent lower than in the corn, wheat, clover rotation. It has been impossible to secure stands of timothy that have been entirely free from clover as there has always been some volunteer clover.

The yield of wheat in the beans, wheat, clover rotation was slightly larger than in the corn, wheat, clover rotation, but the yield of oats in the beans, oats, clover rotation were slightly lower than in the corn, oats, clover rotation. Conclusions in regard to the relative effect of corn and beans in these rotations should be reserved until additional data are secured. The yields of all the crops in the potatoes, rye, clover rotation were slightly higher than in the potatoes, wheat, clover rotation, though the total value of the crop was approximately the same. In both these rotations the yields of small grain and hay were slightly higher than in the corn, rye, clover; and corn, wheat, clover rotations.

In the beets, oats, clover rotation the average yield of beets has been rather small (5.61 tons per acre) principally on account of the soil being poorly adapted to this crop. The average yield of oats, however, has been fairly good and the yield of clover has been larger than from any of the other rotation plats.

The beets, corn, clover and the corn, beets, clover rotations have not proved to be practical rotations, both on account of the two cultivated

crops in the three-year rotation and the difficulty in securing stands of clover. In the latter rotation soy beans have been planted each year after the failure of the clover.

In the beets, corn, clover rotation the clover has been seeded in the corn at the last cultivation and under favorable conditions gives fairly good results, but is rather unreliable as a general farm practice. Soy beans were used as a substitute for clover in 1914. In the corn, beets, clover rotation, clover was seeded in the spring in 1911-12 and 13 but was unsuccessful, making an inferior stand and poor growth and being very weedy. Soy beans have been grown on these plats in 1914-15 and 16.

The yields of the plats devoted to the growing of the same plats continuously have, of course, varied considerably according to the seasons. However, a comparison of average yields for the first and second three-year periods, as given in Table 7 will be of interest.

TABLE VII.—AVERAGE YIELDS OF CROPS GROWN CONTINUOUSLY ON SOME PLATS.

	Average yield 1911-12-13.	Average yield 1914-15-16.
Wheat	22.4	17.0
Corn	38.8	18.3
Beans	13.2	5.0
Beets	7.0	2.1
Potatoes	126.1	34.2

The average decrease of the above crops from the first to the second three-year period was 63 percent. These plats have already come into a very unproductive condition, in most cases the crop being insufficient to pay the cost of production. This has been especially true in case of the bean plat where the growth has been very small and the disease conditions very severe and in the sugar beet plat where it has been impossible the past three seasons to secure good stands even by resorting to reseeding and transplanting the beets from a plat of healthy beets. The practice of introducing beans or beets or cultivated crops, or even the small grains, too frequently in the rotation, should be strongly condemned.

The average yield of alfalfa, 2.13 tons per acre, is not as high as it should be. It should be explained, however, that this includes the first season of the experiment in which the alfalfa was seeded and no crop harvested, and also that it became necessary to re-seed in 1913 and 1915. The re-seeding was necessitated in part, at least, by the very unfavorable weather after seeding and probably also on account of insufficient supply of lime.

The timothy in Plat 0 has produced an average yield of 1.23 tons per acre. The timothy has not made a large growth, especially after it has been seeded two or more seasons, and Kentucky blue grass has to a large extent taken possession of the plat. There has been a small amount of volunteer clover and some weeds, also. In 1913 the plat was plowed after removing the crop of hay and re-seeded in September. However, it is again evident that the timothy cannot maintain its possession of this land in competition with the Kentucky blue grass.

The total value of crops per rotation, as given in Table 8 should not

be accepted as showing the relative value of the several rotations because of the wide variation in the cost of production and because of other factors which determine the choice of crops and the system of farming.

TABLE VIII.—AVERAGE YIELD AND VALUE OF CROPS GROWN IN ROTATION, 1911-1915.

Rotation.	Average yield per acre. Grain in bushels. Beets and hay in tons.			Average annual value of crops.
	Corn.	Small grain.	Hay.	
Corn, oats, clover	38.4	46.7	1.26	$19.39
Corn, rye, clover	41.5	27.1	1.47	21.36
Corn, wheat, clover	39.8	25.2	1.39	21.48
Corn, wheat, timothy	37.5	22.6	1.41	20.23
	Beans.			
Beans, wheat, clover	15.6	28.5	1.26	21.85
Beans, oats, clover	12.7	42.3	1.40	17.72
	Potatoes.			
Potatoes, wheat, clover	127.2	31.2	1.36	35.09
	Beets.			
Beets, oats, clover	5.21	46.0	1.76	20.68
	Corn.	Beans.	Soy beans.	
Corn, beans, clover or soy beans	34.6	12.0	11.0	23.32
Beans, continuously	....	11.6	....	20.30
		Wheat.		
Wheat, continuously	....	23.2	....	20.88
Corn, continuously	36.2	....	....	25.34
	Beets.			
Beets, continuously	5.9	....	....	29.50
	Potatoes.			
Potatoes, continuously	93.2	....	....	46.60
Timothy, continuously	....	....	1.16	11.60
Alfalfa, continuously	....	....	2.31	23.10

ACKNOWLEDGMENTS.

Previous to the beginning of this experiment the various members of the station staff were consulted in regard to the plans of the experiments, arrangement of plats, etc., and many valuable suggestions were offered.

During the progress of the experiment the Soils Department has assisted in surveying of the drainage system, and the Chemistry Division has assisted by making chemical analyses of soil samples and fertilizers.

In 1911, Mr. C. L. Coffeen, then a senior student, and in 1912-13 and 1914, Mr. H. A. Lindsey assisted with the culture and care of the plats. In 1915 the plats were under the direct charge of Mr. R. H. Bamer, and in 1916 in charge of Mr. E. E. Down.

The author wishes to express his appreciation for the services of all those who have assisted, either in the planning or carrying out of this experiment.

REPORT OF THE SOIL PHYSICIST.

Director R. S. Shaw:

I take pleasure in submitting to you the report of the Department of Soils for the fiscal year ending June 30, 1917.

The various lines of experimental work are progressing in a satisfactory manner, the members of the department pursuing their work with vigor and enthusiasm. Although it is not advisable to present data at this time showing results of soil treatment at the various county farms, striking results are being obtained. As stated in the 1916 report, we plan to take up this line of work in a number of counties. During the year satisfactory arrangements were made with the officials in charge of the Cass county farm and a rather elaborate experiment station project was begun. In addition, a smaller project was begun on the Manistee county farm.

The chemical and physical studies of the soil classes found in Cass, Van Buren, Allegan, Ingham, Manistee, Mason and Wexford counties are well under way. The composition of several samples taken in St. Joseph, Allegan and Ingham counties appear in the following tables:

ST. JOSEPH COUNTY.

The soils of St. Joseph county may be classified under five general heads. A brief description of these groups together with the pounds of plant food contained in the surface soil of representative samples is given below:

Level sands originally timbered with oak.

P	K	N	Ca	Mg
610	22265	1354	10098	5936
964	26886	1385	8157	2643

Level sandy soils containing considerable gravel and originally timbered with oak.

P	K	N	Ca	Mg
833	23143	1734	7832	2425

Level loam prairie soils.

P	K	N	Ca	Mg
1206	26729	3422	9760	5800
950	24466	1588	10098	4860

Rolling sandy loam somewhat stony and having sandy subsoils. These soils originally grew maple and beach.

P	K	N	Ca	Mg
1312	28331	2568	11078	......
1076	31191	2085	8390	6013

Rolling sandy loams with heavy subsoils. The original timber was beech, maple and oak.

P	K	N	Ca	Mg
1275	28834	2654	12102	5294

ALLEGAN COUNTY.

The soils of Allegan county may be divided into five principal groups. A brief description of these with the pounds of plant food contained in the surface soil of typical samples is given below:

Low lying darker colored sands originally growing oak and some walnut.

P	K	N
628	20985	3170
762	23085	2980

High light colored sands, growing originally pine, hemlock and some maple.

P	K	N
524	23309	2070
786	30163	2190

Heavy black clay. Originally timbered with elm, oak, maple.

P	K	N
838	39017	8340

Light colored upland clay loam growing elm, soft maple, basswood and some oak and hickory.

P	K	N
750	35830	3960
1209	25508	4720

Upland sandy loam growing mostly oak.

P	K	N
650	22566	1590
873	24827	1560

INGHAM COUNTY.

The soils of Ingham county may be divided into three groups with regard to the method of formation. The till plains, morains and outwash plains. The till plains are composed chiefly of loams, silt loams and clay loams. The soils are known among the farmers as "beech and maple" lands. The composition in pounds per acre of the surface soil, of representative samples is shown below:

	P	K	N	Ca	S
Loam	658	35860	2240	11607	1193
	876	38290	2914	22628	1215
Silt L'm	1947	38250	7616	31602	1629
	829	44570	2196	14714	949
Cl'y L'm	1317	43020	3614	9204	1010

About ¼ to ⅓ of the till plains area is composed of sandy loam. These soils were originally covered with beech, maple, oak and basswood. The plant food contained in the surface soil of representative samples is shown below:

P	K	N	Ca	S
1169	31890	3756	13658	1166
718	33170	2352	10728	956

The morains are composed principally of sandy loams although there are some silt loams, loam and sand. The sandy loams originally grew beech, maple, elm, oak and hickory. The pounds of plant food in the surface soil are shown below:

P	K	N	Ca	S
1325	28370	2296	11930	1037
869	31160	1064	8970	613

The sands are characterized by growths of scrub oak and poplar with some maple and elm in the more fertile areas. The composition of these soils is shown below:

P	K	N	Ca	S
1118	25190	1036	9778	668
865	27710	1176	10200	620

The outwash plains area consists almost entirely of medium sands which grew oak and poplar. The variableness in composition of these sands is shown in the table below:

P	K	N	Ca	S
563	23530	1288	8441	936
1044	25120	980	11373	507

The above results suggest that phosphorous is an important consideration for increased crop production, and the permanent systems of agriculture, field experiments are bearing out these suggestions.

Galvanized iron cans 2 feet in diameter and 2-4-6 and 8 feet in length were sunken in the ground, filled with coloma sand typical of large areas in Michigan, and covered with glass to prevent water from entering. Each tank was constantly supplied with water by means of a block tin tube in the bottom connected with a reservoir. In the spring of 1916 these tanks were seeded to oats and the surface soil watered un-

til the plants had made a good start. Surface watering was then discontinued. In the tank two feet in height the plants grew to maturity and appeared normal. In the tank four feet in height a few weak plants grew to be six to eight inches high and then died, the majority of the plants, however, died shortly after surface watering was discontinued.

In the six and eight feet tanks the plants died as soon as surface watering was discontinued. From these results it appears that the water table in sands of this character must be very near the surface in order to grow normal crops. This conclusion is borne out by field observations. In the northern part of the state a large area of sand was drained by the construction of a large dredge ditch. The ditch was dug extremely deep thus lowering the water table to such an extent that crops could not be grown successfully on the area when the rainfall was low. It was found necessary to dam the ditch in order to raise the water table before satisfactory crops could be grown.

A preliminary report of results obtained from studying the composition and concentration of the soil solution as measured by the freezing point lowering of the root and leaves of plants, appear in Soil Science Vol. III, pages 113-138, 1916. This project is being continued and promises to be a fertile research field.

The movement of soluble salts through soils of different texture and water content, together with the changes induced in the composition of the soil solution in various layers are being studied. The results obtained show that salts move from regions of high to those of lower concentration even in closed containers, such movement being accompanied by changes in the composition of the soil solution. Field studies are underway to determine to what extent, if any, soluble salts rise from the subsoils.

The lime and green manure studies mentioned in last year's report are being continued. In the latter, comparisons of the lasting effect of limestone of different fineness of division, marl and hydrated lime are being made. It is proposed to make an exhaustive study of this problem.

During the year, R. S. Bogan made comparisons of the lime requirement of soils as determined by the Jones, Veitch, and Freezing Point methods respectfully. A large number of widely different samples of soil taken from several counties were employed. In all cases virgin soils were compared with those that had been cropped many years—in most cases until "catches" of clover were impossible without the use of lime or stable manure. The result presented reveals that the virgin soils often show a higher lime requirement than those cropped many years, upon which clover fails. Moreover, the methods give different results for the same soil samples. It thus seems that laboratory methods for determining the lime requirement of soils for maximum returns may be misleading. We are forced to so conclude when we recall that the virgin soils as a rule would doubtless produce many excellent crops of clover without the use of either lime or manure. It seems that the field trial method is the only reliable one to use to determine the optimum amount of lime to apply.

TABLE III.—LIME REQUIREMENT OF SOILS.

INGHAM COUNTY SOILS CaO REQUIREMENT.

Soil class.	Condition.	Jones.	Veitch.	Freezing point.
Sandy	Virgin	0	0	3,703
	Cropped 60 years	580	0	2,380
Sandy loam	Virgin	774	213	7,406
	Cropped 65 years	625	426	5,290
Loam	Virgin	175	746	3,610
	Cropped 70 years	1,102	1,705	6,188
ALLEGAN COUNTY SOILS.				
Medium soil	Virgin	1,705	2,785	6,188
	Cropped 60 years	850	1,134	1,805
Fine sand	Virgin	3,640	4,435	9,283
	Cropped 30 years	....	....	7,540
ST. JOSEPH COUNTY SOILS.				
Sand	Virgin	400	2,369	4,126
	Cropped 80 years	490	3,487	4,126
Fine sand	Virgin	850	3,502	8,251
	Cropped 75 years	850	2,172	6,704
Loam	Virgin	1,524	4,848	10,830
	Cropped 70 years	1,615	4,332	6,188

The report of Dr. G. J. Bouyoucos, research associate in Soil Physics is as follows:

"It is very pleasing to report that the experimental work under the Adams fund is progressing very satisfactorily. The problems under immediate investigation are as follows: (1) Measuring the different forms of water in the soil by means of the dilatometer method; and (2) studying the rate of reaction between soils and salts, acids and bases and the behavior of the equilibrium by means of the freezing point method. Both of these problems are about completed and the data are being prepared for publication. The results obtained from both problems are exceedingly gratifying. They furnish some very important and fundamental information regarding the form in which the moisture exists in the soil and the rate at which equilibrium is attained in the reaction between soils, and salts, acids, and bases.

The problem for the ensuing fiscal year will consist of different phases of these two main lines of work. They have not been definitely selected, however, and consequently their exact titles cannot be announced at this time.

During the past fiscal year, two publications were issued from the investigations under the Adams fund, namely, Bulletin 31, entitled "Further Studies on the Freezing Point Lowering of the Soils," and a lengthy article published in the Journal of Agricultural Research V. VIII, February, 1917, entitled "Measurement of the Inactive or Unfree Moisture in the soil by means of the dilatometer method."

Again I desire to express the gratitude of the various members of the

department to you, for your support and encouragement in our Experiment Station activities during the past year.

Respectfully submitted,
M. M. McCOOL,
Soil Physicist.

East Lansing, Mich., June 30, 1917.

REPORT OF THE DIVISION OF FARM MECHANICS.

Director R. S. Shaw, College:

Dear Sir—Following is a brief report on the work carried on by the Division of Farm Mechanics for the year ending June 30, 1917:

For the past two years interest has been manifested in the application of marl to soils as a substitute for lime. Much of the marl is located in beds underlying small marshes and lakes and is, therefore, inaccessible by ordinary means of excavation. These beds are also too small or inaccessible to transportation facilities to make a large commercial plant profitable. A demand has grown for some means of obtaining the submerged marl for use in the vicinity of the bed.

A small plant which could be owned by a group of 4 or 5 farmers or a small contractor, and which could be made portable, has seemed desirable. A thorough investigation of manufactured equipment of this nature showed nothing which would meet the requirements either as to investment or practicability. Some investigation was made of methods attempted to handle marl under the conditions named. From these observations and a study of the marl beds it appeared that the diaphragm pump could be used. Pumping tests with this type of pump showed that marl more than 50% solid could be pumped efficiently. Field tests indicated, however, that the marl did not flow freely enough to keep the suction hose filled and consequently too great a volume of water was pumped. To exclude the water a bell-shaped end was used on the suction hose, having an internal hand-operated agitator for cutting the marl. Tests of various kinds of agitators showed them to be inadequate and consequently it became difficult to sink the bell as fast as the marl could be pumped. As the simplest means of securing mechanical agitation a machine having a movable arm, similar to a bucket dredge arm,—this arm carrying the suction hose, and a scoop at the end of the arm was devised. This scoop is designed to deliver the marl to the suction hose, from whence it could be pumped and delivered through hose or pipe to any reasonable distance to the shore or solid ground. This machine has not been completed so results cannot be given.

Practically the only question to be worked out in this problem is that of agitating and starting the marl. It has been demonstrated that it can be pumped efficiently, that it can be conveyed through troughs or piping, and that it can be drained and dried by allowing to stand for some time; also that it can be handled satisfactorily when dried with a wagon or manure spreader.

It is recommended that experiments be continued further at least until the feasibility of pumping be determined.

Beside the marl handling experiments very little investigational or experimental work has been carried. I have been consulted by others of the station staff with reference to Station work, which I have been glad to do. I have also called upon others and received valuable suggestions for which I wish to commend the spirit of cooperation shown.

Respectfully submitted,

H. H. MUSSELMAN,

Associate Professor of Farm Mechanics.

East Lansing, Mich., June 30, 1917.

BULLETINS

OF THE

Agricultural College Experiment Station

ISSUED DURING THE

YEAR ENDING JUNE 30, 1917.

COMMERCIAL FEEDING STUFFS.

Bulletin No. 276.

BY ANDREW J. PATTEN, E. F. BERGER, A. E. SMOLL
AND E. A. DE WINDT.

The law regulating the licensing and sale of commercial feeding stuffs and providing for the inspection and analysis of such feeding stuffs was first enacted in 1905 and its administration was delegated to the Dairy and Food Commissioner. By an amendment passed by the legislature during the session of 1915, the Secretary of the State Board of Agriculture was made the administrative officer. The inspection and chemical analyses as well as all matters relating thereto are now performed by the Chemical Division of the Experiment Station to whom all inquiries regarding the work should be addressed.

The present law became operative August 20th, 1915, but as no funds were transferred to the State Board of Agriculture it was not possible to start the inspection work until sufficient funds had accumulated from license fees to cover the necessary expenses. The first inspector began work early in January, 1916, and in February three more inspectors were put to work in order to cover the entire State as thoroughly as possible before the shipping season should close. Nearly 1,200 samples were collected, of which, 1,060 have been analyzed. The results of the analyses and comments thereon will be found in the following pages.

The full text of the Feeding Stuffs law has been printed in pamphlet form and copies may be obtained by addressing the Chemical Division, Experiment Station, East Lansing, Michigan. Although the law has been on the statute books for more than ten years there seems to be a widespread misunderstanding of its requirements on the part of manufacturers, dealers and consumers. The more important points of the law are, therefore, given special notice at this time.

Label. The law requires that each package of commercial feeding stuff shall bear, in a conspicuous place, a printed statement certifying the number of *net* pounds in the package, the name or trade mark under which it is sold, the name and principle address of the manufacturer or shipper and a chemical analysis, stating the percentages of crude protein, crude fiber, ether extract (fat) and nitrogen-free extract (carbohydrates). This information may be printed on the bag itself or on a tag attached to the bag. When feed is sold in bulk this information must be furnished to each purchaser. The law does not specify the form of stating the guaranteed analysis but the following simple form is recommended:

Crude protein, Minimum	—%
Ether extract (fat), Minimum	—%
Nitrogen-free extract (carbohydrates), Minimum ...	—%
Crude fiber, Maximum	—%

The sliding guarantee should be abandoned as quickly as possible for it has a tendency to mislead and confuse the purchaser. The attention of the consumer is directed to the fact that where the sliding guarantee is used, the higher figures are less frequently maintained than the lower ones.

Materials Subject to License. The term concentrated feeding stuff includes linseed meal, cottonseed meal, pea meal, cocoanut meal, gluten meal, oil meals of all kinds, gluten feeds, maize feeds, starch feeds, mixed sugar feeds, hominy feed, rice meal, oat feeds, corn and oat feeds, meat meal, dried blood, clover meals, mixed feeds of all kinds, slaughter house waste products, all condimental stock foods, patented and proprietary stock foods claimed to possess nutritive properties and all materials intended for feeding to domestic animals except hays, straws, fodders, ensilage, the whole seeds and the unmixed meals made directly from grinding the entire grains of wheat, rye, barley, oats, flaxseed, maize, buckwheat, wet brewers' grains, malt sprouts, wet or dried beet pulp *when unmixed with other materials.* It also exempts wheat, rye, and buckwheat brans and middlings when unmixed with other substances, and pure grains ground together.

The opinions held by the administrative officers in regard to a few special feeds over which there has been considerable discussion is here stated.

Wheat Bran with Ground Screenings not Exceeding Mill Run. Almost the first problem to be confronted was the position to be taken in regard to the status of wheat bran with screenings in relation to the law. After making quite an extensive investigation of the subject and writing many letters we were convinced that, under normal conditions, wheat bran should not contain foreign material in excess of one or two per cent and, that the presence of a greater amount was evidence of the addition of screenings.

Screenings were held to be "other substances" and that a mixture of wheat bran and screenings should be classed as a mixed feed and be subject to the requirements of the law.

Before making a definite ruling on this point the matter was presented to the Attorney General for an opinion which is herewith printed in full:

"It will be noted that the exemption in section 2 with reference to wheat, rye and buckwheat brans contains the specific requirement that the same shall not be mixed with "other substances." This of course must be taken to mean that if bran is so mixed it can not be deemed to be relieved from the requirements imposed. I scarcely think that the conclusion can be avoided that screenings even though taken from the same grain from which the bran is produced must be regarded as another substance as such expression is used in the exempting clause referred to. It follows, therefore, that such a mixture as is indicated by your inquiry must be considered as subject to the provisions of Section 2 and can not reasonably be said to be relieved by virtue of any of the exceptions in the concluding sentences of that section. Any person or persons therefore that wish to sell such a mixture should comply with the Act. If a tag or label is placed on such a product indicating that it consists of bran and screenings, without reference to the proportion of the latter, it is thereby indicated that such product is

one to which this Act applies. Any other construction would obviously open the way to evasions of the statute."

The same ruling applies to wheat middlings, rye and buckwheat brans and middlings.

Poultry Foods. The point has been raised that poultry feeds consisting wholly or in part of a mixture of whole grains should be exempt from the provisions of the law but inasmuch as all samples of this class of feed coming under our attention have contained one or more "other materials" in the form of weed seeds, screenings, charcoal, grit, etc., it is absolutely impossible to come to any other decision than that they are subject to the provisions of the law. The opinion of the Attorney General is given on this subject also:

"You submit the further inquiry as to whether or not poultry foods that consist of a mixture of grains and other substances are subject to this Act. The answer to this question also depends upon the construction placed on the exempting clauses of Section 2. In accordance with these clauses whole seeds are not to be regarded as "feeding stuffs" within the meaning of the expression as used in the Act. While the intention of the Legislature is not clearly indicated, I am inclined to the opinion that the language used should be construed to mean that a feeding stuff consisting entirely of the whole seeds of one grain, or consisting of the whole seeds of a number of the grains, specifically named in the Statute, should not be regarded as subject to the provisions thereof. On the other hand, a mixture of these grains, or any of them, with other substances that are commonly placed in poultry foods would clearly seem to be mixed feed and as such within the provisions of the statute."

Ruling concerning Grit in Poultry Food.

It is held that a single registration may cover a poultry food either with or without grit provided the brand name and guaranteed analysis are the same in both cases. The presence of grit may be indicated under the list of ingredients, where these are printed on the bag without constituting any change in the brand name, however, the addition of the words "and grit" to the brand name would necessitate a separate registration.

Corn and Oat Feeds. When the pure grains of corn and oats are ground together without the admixture of other substances the product is exempt from the provisions of the law but the product resulting from the mixing of corn feed meal with ground oats or oat by-products is subject to the provisions of the law and should be licensed before being placed on sale in the State.

License Fee. The license fee as fixed by law is $20.00 for each brand of commercial feeding stuff as defined in the statute and should be paid to the Secretary, State Board of Agriculture, East Lansing, Michigan, on or before April 1st of each year or before the feed is placed on sale.

When the manufacturer pays the fee the dealer is not required to pay an additional fee but in case the manufacturer fails to pay the fee, the dealer then becomes responsible. Therefore, when purchasing feeds from parties outside the State for resale the dealer should make sure that they have been properly registered and that the license fees have been paid. A list of manufacturers and the feeds licensed by each, for the year ending April 1st, 1917, will be found on pages 61-72.

Sampling. Any duly authorized agent of the State Board of Agriculture is empowered to select samples, for the purpose of analysis,

from any lot of commercial feeding stuffs offered or exposed for sale within the State. All inspectors sent out for this purpose are provided with an authorization signed by the Secretary of the State Board of Agriculture, and only such persons have authority to collect samples for the purpose of analysis.

COOPERATION WITH THE U. S. DEPARTMENT OF AGRICULTURE.

The Chemist in charge of the feeding stuffs inspection holds a commission from the Secretary of Agriculture which gives to the inspectors authority to collect samples of interstate shipments under the Federal Food and Drugs Act. By this means action is secured against the parties responsible for sending low grade or adulterated feed into the State.

This cooperative arrangement has worked very satisfactorily during the past season when 32 cases were referred to the Federal laboratory at Chicago.

DEFINITIONS.

The following definitions of Feeding Stuffs and by-products used for feeding purposes have been adopted by the Association of Feed Control Officials of the United States at their several meetings, and, in the interest of uniformity, it is urged that all manufacturers and millers adhere to them as closely as possible in labeling the feeds intended for sale in Michigan.

Meal is the clean, sound, ground product of the entire grain, cereal or seed which it purports to represent.

Chop is a ground or chopped feed composed of one or more different cereals or by-products thereof. If it bears a name descriptive of the kind of cereals, it must be made exclusively of the entire grains of those cereals.

Screenings are the smaller imperfect grains, weed seeds and other foreign material having feeding value, separated in cleaning the grain.

Alfalfa Meal is the entire alfalfa hay ground, and does not contain an admixture of ground alfalfa straw or other foreign materials.

ANIMAL PRODUCTS.

Blood Meal is ground dried blood.

Meat Scrap and Meat Meal are the ground residues from animal tissue exclusive of hoof and horn. If they contain any considerable amount of bone, they must be designated Meat and Bone Scrap, or Meat and Bone Meal. If they bear a name descriptive of their kind, composition or origin, they must correspond thereto.

Digester Tankage is the residue from animal tissue exclusive of hoof and horn, specially prepared for feeding purposes by tanking under live steam, drying under high heat, and suitable grinding. If it contains any considerable amount of bone, it must be designated Digester Meat and Bone Tankage.

Cracklings are the residue after partially extracting the fats and oils from the animal tissue. If they bear a name descriptive of their kind, composition or origin, they must correspond thereto.

BREWERS' AND DISTILLERS' PRODUCTS.

Brewers' Dried Grains are the properly dried residue from cereals obtained in the manufacture of beer.

Distillers' Dried Grains are the dried residue from cereals obtained in the manufacture of alcohol and distilled liquors. The product shall bear the designation indicating the cereal predominating.

Malt Sprouts are the sprouts of the barley grain. If the sprouts are derived from any other malted cereal, the source must be designated.

BUCKWHEAT PRODUCTS.

Buckwheat Shorts or Buckwheat Middlings are that portion of the buckwheat grain immediately inside of the hull after separation from the flour.

CORN PRODUCTS.

Corn Bran is the outer coating of the corn kernel.

Corn Feed Meal is the sifting obtained in the manufacture of cracked corn and table meal made from the whole grain.

Corn Germ Meal is a product in the manufacture of starch, glucose and other corn products and is the germ layer from which a part of the corn oil has been extracted.

Grits are the hard, flinty portions of Indian corn, without hulls and germ.

Hominy Meal, Hominy Feed or *Hominy Chop* is a mixture of the bran coating, the germ and a part of the starchy portion of the corn kernel obtained in the manufacture of hominy grits for human consumption.

Corn Gluten Meal is that part of commercial shelled corn that remains after the separation of the larger part of the starch, the germ and the bran, by the processes employed in the manufacture of cornstarch and glucose. It may or may not contain corn solubles.

Corn Gluten Feed is that portion of commercial shelled corn that remains after the separation of the larger part of the starch and the germ by the processes employed in the manufacture of cornstarch and glucose. It may or may not contain corn soluble.

COTTONSEED PRODUCTS.

Cottonseed Meal is a product of the cottonseed only, composed principally of the kernel with such portion of the hull as is necessary in the manufacture of oil; provided that nothing shall be recognized as cottonseed meal that does not conform to the foregoing definition and that does not contain at least 36 per cent of protein.

Choice Cottonseed Meal must be finely ground, not necessarily bolted, perfectly sound and sweet in odor, yellow, free from excess of lint and must contain at least 41 per cent of protein.

Prime Cottonseed Meal must be finely ground, not necessarily bolted, of sweet odor, reasonably bright in color, yellow, not brown or reddish, free from excess of lint, and must contain at least 38.6 per cent of protein.

Good Cottonseed Meal must be finely ground, not necessarily bolted, of sweet odor, reasonably bright in color, and must contain at least 36 per cent of protein.

Cottonseed Feed is a mixture of cottonseed meal and cottonseed hulls containing less than 36 per cent of protein.

Cold Pressed Cottonseed is the product resulting from subjecting the whole undecorticated cottonseed to the cold pressure process for the extraction of oil, and includes the entire cottonseed less the oil extracted.

Ground Cold Pressed Cottonseed is the ground product resulting from subjecting the whole undecorticated cottonseed to the cold pressure process for the extraction of oil, and includes the entire ground cottonseed less the oil extracted.

LINSEED AND FLAX PRODUCTS.

Flax Plant By-Product is that portion of the flax plant remaining after the separation of the seed, the bast fiber and a portion of the shives, and consists of flax shives, flax pods, broken and immature flax seeds and the cortical tissue of the stem.

Linseed Meal is the ground product obtained after extraction of part of the oil from ground flaxseed screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes.

Oil Meal is the ground product obtained after the extraction of part of the oil by crushing, cooking and hydraulic pressure, or by crushing, heating and the use of solvents from seeds which have been screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes. When used alone the term "oil meal" shall be understood to designate the product obtained from screened and cleaned flaxseed. When used to cover any other product the name of the seed from which it is obtained shall be prefixed to the words "oil meal."

Old Process Oil Meal is the ground product obtained after extraction of part of the oil by crushing, cooking and hydraulic pressure from seeds screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes. When used alone the term "old process oil meal" shall be understood to designate the product obtained from partially extracted, screened and cleaned flaxseed. When used to cover any other product the name of the seed from which it is obtained shall be prefixed to "old process oil meal."

New Process Oil Meal is the ground product obtained after extraction of part of the oil by crushing, heating and the use of solvents from seeds screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes. When used alone the term "new process oil meal" shall be understood to designate the product obtained from partially extracted, screened and cleaned flaxseed. When used to cover any other product the name of the seed from which it is obtained shall be prefixed to "new process oil meal."

Unscreened Flaxseed Oil Feed is the ground product obtained after extraction of part of the oil from unscreened flaxseed by crushing, cooking and hydraulic pressure, or by crushing, heating and the use of solvents. When sold without grinding and the unground product shall be designated as "unscreened flaxseed oil feed cake."

Ingredients of Unscreened Flaxseed Oil Feed—Ground cake from partially extracted flaxseed and foreign seeds (wheat, wild buckwheat, pigeon grass, wild mustard, etc.)

Screenings Oil Feed is the ground product obtained after extraction

of part of the oil by crushing, cooking and hydraulic pressure, or by crushing, heating and the use of solvents from the smaller imperfect grains, weed seeds and other foreign materials having feeding value separated in cleaning the grain. The name of the grain from which the screenings are separated shall be prefixed to "screenings oil feed."

OAT PRODUCTS.

Oat Groats are the kernels of the oat berry.

Oat Hulls are the outer chaffy coverings of the oat grain.

Oat Middlings are the floury portion of the oat groat obtained in the milling of rolled oats.

Oat Shorts are the covering of the oat grain lying immediately inside the hull, being a fuzzy material carrying with it considerable portions of the fine floury part of the groat obtained in the milling of rolled oats.

Clipped Oat By-Product is the resultant by-product obtained in the manufacture of clipped oats. It may contain light, chaffy material broken from the ends of the hulls, empty hulls, light, immature oats and dust. It must not contain an excessive amount of oat hulls.

RICE PRODUCTS.

Rice Bran is the cuticle beneath the hull.

Rice Hulls are the outer chaffy coverings of the rice grain.

Rice Polish is the finely powdered material obtained in polishing the kernel.

WHEAT PRODUCTS.

Wheat Bran is the coarse outer coatings of the wheat berry obtained in the usual commercial milling process from wheat that has been cleaned and scoured.

Shorts or Standard Middlings are the fine particles of the outer and inner bran separated from bran and white middlings.

Wheat White Middlings or *White Middlings* are that part of the offal of wheat intermediate between shorts or standard middlings and red dog.

Shipstuff or *Wheat Mixed Feed* is a mixture of the products other than the flour obtained from the milling of the wheat berry.

Red Dog is a low grade wheat flour containing the finer particles of bran.

Wheat Bran with Mill Run Screenings is pure wheat bran plus the screenings which were separated from the wheat used in preparing said bran.

Wheat Bran with Screenings not Exceeding Mill Run is either wheat bran with the whole mill run of screenings or wheat bran with a portion of the mill run of screenings, provided that such portion is not an inferior portion thereof.

Yeast or Vinegar Dried Grains are the properly dried residue from the mixture of cereals, malt and malt sprouts (sometimes cottonseed meal) obtained in the manufacture of yeast or vinegar, and consist of corn or corn and rye from which most of the starch has been extracted, together with malt added during the manufacturing process to change the starch to sugars, and malt sprouts (sometimes cottonseed meal) added

during the manufacturing process to aid in filtering the residue from the wort and serve as a source of food supply for the yeast.

Oil Cake is the residual cake obtained after extraction of part of the oil by crushing, cooking and hydraulic pressure from seeds screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes. When used alone the term "oil cake" shall be understood to designate the product obtained from partially extracted, screened and cleaned flaxseed. When used to cover any other product, the name of the seed from which it is obtained shall be prefixed to "oil cake."

Ground Oil Cake is the product obtained by grinding oil cake. When used alone, the term "ground oil cake" shall be understood to designate the product obtained from partially extracted, screened and cleaned flaxseed. When used to cover any other product the name of the seed from which it is obtained shall be prefixed to "ground oil cake."

Ground Flaxseed or Flaxseed Meal is the product obtained by grinding flaxseed which has been screened and cleaned of weed seeds and other foreign material by the most improved commercial processes.

Palm Kernel Oil Meal is the ground residue from the extraction of part of the oil by pressure or solvents from the kernel of the fruit of the Elaeis guineensis of Elaeis malanococca.

Ivory Nut Meal is ground ivory nuts.

Peanut Oil Cake is the residue after the extraction of part of the oil by pressure or solvents from peanut kernels.

Peanut Oil Meal is the ground residue after the extraction of part of the oil from peanut kernels.

Unhulled Peanut Oil Feed is the ground residue obtained after extraction of part of the oil from whole peanuts, and the ingredients shall be designated as "peanut meal and hulls."

DISCUSSION OF RESULTS.

An examination of the tables of analyses will show that a large number of samples were found to be below guarantee in one or more constituents. In estimating the number of violations the following tolerances are allowed crude protein 1.00 per cent and crude fat 0.50 per cent.

Of the 1,060 samples analyzed 223 (21.0%) were found to be deficient in either protein or fat. One hundred fifty-nine samples (15%) were deficient in protein and 122 (11.5%) in fat. Seventy-six of the violations were found among the cottonseed meals, 21 among the mixed dairy feeds, 26 among the wheat brans and 25 among the poultry feeds. These results reveal a condition that was to be expected since a rigid inspection of the feeds being sold in the State has never before been made. A more complete analysis of the results will be made under the different classified groups which follow.

COTTONSEED MEAL.

One hundred forty-four samples of cottonseed meal and one sample each of cottonseed cake and cottonseed feed were collected representing 19 different manufacturers or shippers. Of this number 76 (53%) were found to be deficient in either protein or fat. Seventy-five (51%) samples were below guarantee in protein and 9 (6.2%) were below in fat. In

the majority of cases the deficiency in protein was accompanied by an excess in fiber or hulls.

This condition, as explained by the manufacturers, is due to an unusual demand on the part of the munition manufacturers for lint or short fiber cotton. To meet this demand the seed has been cleaned more thoroughly than ever before which has made it more difficult to maintain the quality of the meal to that of the present standards. While such a condition may, perhaps, be unavoidable under the existing conditions, there is, certainly, no good reason why the manufacturers and shippers should not have frankly made the facts known to the buyers and lowered their guarantees to conform to the actual analysis of the meal.

An examination of the tables of analyses will show which companies were most derelict in fulfilling their obligations to the buyers.

LINSEED MEAL.

Forty-six samples of linseed meal representing 13 manufacturers or shippers were received, only two of which were found to be low guarantee in protein. Some of the samples contained an excessive amount of screenings and other foreign materials.

FLAXSEED MEAL.

Four samples of flaxseed meal were collected and analyzed. None of the samples carried a guaranteed analysis as pure flaxseed meal is exempt from the provisions of the law.

Two of the samples contained excessive amounts of screenings and other foreign materials and on presenting the fact to the manufacturers they have given assurance that their products will be kept reasonably clean in the future.

DISILLERS' DRIED GRAINS, CHIEFLY FROM CORN.

Seventeen samples of corn distillers' grains were collected. The samples of "Continental Gluten Feed" manufactured by the Continental Cereal Co., Peoria, Illionis, included under this classification, were all below guarantee in both protein and fat. It is significant to note that the average percentages of protein and fat in the five samples were 4.4 per cent and 3.5 per cent respectively below the average for all the other samples of this class while the average price was only 50 cents per ton lower.

CHIEFLY FROM RYE.

Two samples of rye distillers' grains were collected both of which were below guarantee in both protein and fat. Several unofficial samples of this brand were also received from purchasers, the majority of which were found to be below guarantee in protein. The Interstate Feed Association was notified of our findings and also requested to change the guaranteed analysis since which time has been selling under a guarantee of 15 per cent protein.

BREWERS' DRIED GRAINS.

Eight samples of this class of feeds were collected, only one of which was found to be below guarantee. The guarantees for protein and fat varied from 19 per cent and 5 per cent to 30 per cent and 7 per cent respectively while the results found varied from 18.1 per cent and 4.8 per cent to 34.9 and 6.7 per cent respectively. The retail prices quoted ranged from $25.00 to $30.00 per ton. It will be noticed that the variation in price does not follow the variation in composition.

CORN GLUTEN FEED.

Twenty-four samples of corn gluten feed were collected, only four of which were below guarantee. The average analyses of all samples varied from 21.4 per cent to 34.3 per cent protein and from 1.8 per cent to 7.5 per cent fat while the retail prices quoted ranged from $27.00 to $40.00 per ton.

CORN GLUTEN MEAL.

Three samples of corn gluten meal manufactured by the Corn Products Refining Co. were obtained, one of which was below guarantee in fat. In other respects the analyses of the three samples were very uniform.

HOMINY FEEDS.

Of this class of feed, 10 samples were collected, four of which were deficient in fat and two in protein. The retail price quoted ranged from $27.50 to $34.00 per ton. The guarantees for protein and fat varied from 9.5 to 11.3 per cent and 6.0 to 8.5 per cent respectively while the results found varied from 9.6 to 11.0 per cent and 6.1 to 8.0 per cent respectively. The analyses of the various samples agree more closely than the guarantees made by the manufacturers.

CORN FEED MEAL.

Sixteen samples were collected and analyzed under this class, some being pure corn meal for which no license is required. One sample of corn germ meal is also included under this classification.

The moisture content of the samples was found to be very high in several cases and it was noticed that these high moisture samples spoiled very rapidly. In two cases the samples had spoiled before the fat determinations were made.

Three samples were below guarantee in protein and the same number in fat.

The attention of the manufacturers and dealers is directed particularly to the definitions for corn products and it is suggested that the labels be prepared in accordance therewith.

ANIMAL BY-PRODUCTS.

Sixteen samples of feed under this class were collected, two of which were below guarantee in protein and two in fat. These by-products comprised digester tankage, blood and bone meal, meat meal, granulated bone, and meat scraps. In all but one case the labels were in accord

with the character of the feed. The retail prices quoted ranged from $35.00 to $75.00 per ton.

ALFALFA MEAL.

Nine samples of alfalfa meal were collected and analyzed. The analyses of all samples agreed very closely with the exception of B 464, which was considerably above all other samples in protein. The retail prices quoted ranged from $28.00 to $50.00 per ton.

CALF MEALS.

Twenty-one samples of this class were collected representing seven different manufacturers. Four samples were below guarantee in protein and two in fat. The percentage of protein found ranged from 14.4 to 26.6 per cent and the fat from 1.9 to 8.4 per cent. The retail prices quoted ranged from $50.00 to $80.00 per ton.

HOG MEALS.

Twelve samples of "Hog Meal" were collected and analyzed, six of which were found below guarantee in fat.

The chemical analysis of the various samples did not vary greatly but the composition was very different and the retail prices quoted ranged from $26.00 to $80.00 per ton.

DAIRY FEEDS.

Ninety-nine samples of dairy feed were collected and analyzed. Thirteen were found below guarantee in protein and 10 were below in fat. The percentage of protein found varied from 4.7 to 29.5 per cent and the fat from .04 to 7.3 per cent, while the retail prices quoted ranged from $25.00 to $35.00 per ton.

The character of the feeds sold under this class differed very greatly, some being mixtures of bran, malt sprouts, cottonseed meal, linseed meal, etc., and others being composed largely of molasses, alfalfa, screenings, and concentrates such as cottonseed meal, distillers' grains, etc.

There is much room for improvement in the quality of the feeds sold under this classification and purchasers should make a careful examination of all feeds before buying.

HORSE FEEDS.

Seventy-five samples of this class of feeds were collected, about 80 per cent of which were molasses feeds, being composed of alfalfa, cracked corn, oats or oat hulls and molasess. The percentage of protein varied from 7.4 to 14.7 per cent and the fat from 1.1 to 4.4. per cent while the retail prices quoted ranged from $26.00 to $35.00 per ton. Ten of the samples were found to be deficient in fat and one in protein.

POULTRY FEEDS.

Two hundred and twelve samples, comprising chick feeds, scratch feeds and mash feeds were collected and analyzed. Eight were found to be deficient in protein and 19 were deficient in fat. The majority of the

chick and scratch feeds were made up of cracked corn and kaffir corn with varying proportions of sunflower seeds, wheat, oats, buckwheat, barley, oats and weed seeds. The proportion of sunflower seeds was extremely small, seldom amounting to as much as 1 per cent. Weed seeds were found in varying amounts in nearly all samples, in some cases, comprising 25 to 30 per cent of the entire feed. A great variety of weed seeds were identified but wild buckwheat, pigeon grass and lady's thumb were most commonly found. Several of the samples contained cockle and ergot, both of which are poisonous, the latter especially so to young chicks.

Forty-nine samples of scratch feed were free from grit and 48 contained grit in amounts varying from 0.62 per cent to 18.2 per cent, the average for all samples being 5.13 per cent. The average retail price for scratch feed without grit was $1.91 per cwt. while for scratch feed with grit it was $1.89 or only 2 cents per cwt. lower. No successful poultry man can afford to pay the high prices for weed seeds and grit that are now charged for this class of feed and purchasers should demand a product that is reasonably free from these ingredients. In the case of chick feeds there is some reason for including grit but the amount should not exceed 2 or 3 per cent in any case.

CORN AND OAT FEED.

This classification includes various products such as pure ground corn and oats, for which no license is required and mixtures of corn and oat by-products either with or without the addition of other grain by-products. The latter should be licensed before being placed on sale.

Sixty-three samples were collected, only 24 of which were guaranteed. Thirteen (54%) of the guaranteed samples were deficient in fat and 2 (8%) were deficient in protein. Several of the samples had a high moisture content which caused a rapid deterioration of the feed. Oat hulls in varying amounts were present in many of the samples.

WHEAT BRAN.

One hundred and eleven samples of wheat bran were collected and analyzed. Twenty-four of the samples were deficient in protein and 7 in fat. The percentage of protein was found to vary from 12.7 to 18.8 per cent and the fat from 3.1 to 5.7 per cent while the retail prices quoted ranged from $23.00 to $34.00 per ton. Screenings in excess of 2 per cent were found to be present in 50 per cent of the samples, the highest amount determined being 18.83 per cent. In the majority of cases the screenings were unground and consisted of broken wheat, chaff, oat hulls and weed seeds. As many as 13 different kinds of weed seeds were identified in some cases.

Wheat bran with added screenings are held to be subject to the provisions of the law and should be licensed before being placed on sale. They should also be labelled so as to indicate the presence of the screenings.

WHEAT MIDDLINGS.

One hundred nine samples of wheat middlings, including one sample of Red Dog Flour were collected. Eight of the samples were "White"

middlings and the remainder were "Standard" middlings or "Shorts." In the majority of cases the samples were properly labelled although in a few cases screenings were identified where the fact was not indicated on the label.

The percentage of protein found varied from 12.0 to 18.1 per cent and the fat from 2.7 to 6.5 per cent while the retail prices ranged from $22.50 to $35.00 per ton.

WHEAT MIXED FEED.

Eleven samples of wheat mixed feed were collected, 2 of which were deficient in protein and five in fat. The percentage of protein was found to vary from 13.1 to 16.3 per cent and the fat from 3.7 to 5.4 per cent. The retail prices quoted ranged from $24.00 to $31.00 per ton. The feeds under this class are mixtures of wheat bran and middlings with screenings and in many cases floor sweepings. All feeds under this classification should be licensed before being placed on sale.

WHEAT AND RYE MIDDLINGS.

Two samples were collected, one of which was below guarantee in fat. Both samples contained the same amount of fat while the protein varied from 15.7 to 16.5 per cent. The retail prices quoted ranged from $1.50 to $2.00 per cwt.

RYE MIDDLINGS.

Three samples of rye middlings were collected, only one of which was guaranteed. The results show a wide variation in protein from 10.3 to 15.4 per cent and in fat from 1.5 to 3.1 per cent. The retail prices quoted ranged from $14.50 to $28.00 per ton and it is interesting to note that the sample having the lowest selling price contains the largest percentages of protein and fat.

OAT MIDDLINGS.

One sample of coarse oat middlings and two samples of fine oat middlings were collected, all of which were manufactured by the same company. The results found agree very well with an average analysis for these products.

BARLEY BRAN.

Two samples of this class of feed were collected, both of which were above guarantee, the result for protein being more than 100 per cent above guarantee. The results as found agree very well with those given in Henry's "Feeds and Feeding" for barley bran.

CEREAL FOOD BY-PRODUCTS.

Under this classification are included the by-products from the manufacture of breakfast foods. Twenty-five samples were collected, eighteen of which were licensed and guaranteed. Five samples were below guarantee in fat. As the feeds included in this class vary so widely in character no comparison of the composition and retail prices can be made but intending purchasers would do well to study the results given in the following pages:

ANALYSES OF FEEDING STUFFS FOR 1915-1916.

Laboratory Number.	Manufacturer and Trade Name.	Sampled at	Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	COTTONSEED MEAL.						
	American Milling Co., Peoria, Ill.						
		*G	......	41.0	6.5	10.0	....
B 123	Amco Cottonseed Meal........................	Lansing........ *F.	8.4	46.1	6.5	11.0	$45 00
	J. E. Bartlett Co., Jackson, Mich.						
		*G.	......	23.0	7.0	27.0	....
B 691	Acme Cold Pressed Cottonseed Cake.............	Cheboygan..... *F.	7.5	24.1	9.5	24.8	$1 90
		*G.	......	38.5	6 0	12.0	....
B 265	Jersey Farmer Brand Cottonseed Meal...........	Jackson........ *F.	6 9	36 5	6.0	12.9	37 00
B 342	Jersey Farmer Brand Cottonseed Meal...........	Three Oaks...........	8.0	38.8	6.2	11.1	1 95
B 847	Jersey Farmer Brand Cottonseed Meal...........	Frankenmuth.........	6.1	39.3	6.1	10.9	38 00
B 869	Jersey Farmer Brand Cottonseed Meal...........	Farmington...........	7.7	35.4	6.3	12.6	2 00
B 894	Jersey Farmer Brand Cottonseed Meal...........	Romeo...............	8.5	37.0	6.5	13.0	1 90
B 1269	Jersey Farmer Brand Cottonseed Meal...........	Paw Paw.............	6.9	36.8	8.5	12.4	1 90
		Average...........	7.4	37.3	6.6	12.2	....
		*G.	......	41.0	7.0	10.0	....
B 806	Michigan Farmer Brand Cottonseed Meal........	Flint........... *F.	7.7	39.3	6.5	13.5	$38 00
B 1	Michigan Farmer Brand Cottonseed Meal........	Ionia................	8.5	35.2	6.0	14.7	....
B 47	Michigan Farmer Brand Cottonseed Meal........	Saginaw..............	7.4	36.6	6.4	13.7	40 00
B 90	Michigan Farmer Brand Cottonseed Meal........	Bay City.............	7.5	40.4	7.7	8.4	2 00
B 120	Michigan Farmer Brand Cottonseed Meal........	Bay City.............	7.7	39 2	6.8	11.8	....
B 130	Michigan Farmer Brand Cottonseed Meal........	Midland..............	8.1	34.9	6.5	14.2	....
B 270	Michigan Farmer Brand Cottonseed Meal........	Jackson..............	7.9	43.3	6.9	7.0	38 00
B 297	Michigan Farmer Brand Cottonseed Meal........	Detroit..............	6.6	43.8	7.3	6.7	1 95
B 324	Michigan Farmer Brand Cottonseed Meal........	Detroit..............	7.8	42.9	7.5	7.4	1 95
B 380	Michigan Farmer Brand Cottonseed Meal........	Berrien Springs.......	8.0	38.0	6 3	13.2	2 00
B 506	Michigan Farmer Brand Cottonseed Meal........	Coopersville..........	7.5	41.0	6.9	10.6	35 00
B 579	Michigan Farmer Brand Cottonseed Meal........	Greenville............	7.9	39.3	7.1	10.5	45 00
B 683	Michigan Farmer Brand Cottonseed Meal........	Tecumseh............	6.9	39 0	6.7	10.6	1 90
B 801	Michigan Farmer Brand Cottonseed Meal........	....	7.4	42.3	6.9	8.9	38 00
B 827	Michigan Farmer Brand Cottonseed Meal........	Port Huron...........	7.9	40 0	6.5	10.4	1 90
B 832	Michigan Farmer Brand Cottonseed Meal........	Port Huron...........	6.5	42.5	8.6	13.0	39 00
B 851	Michigan Farmer Brand Cottonseed Meal........	Birch Run............	7.8	41.3	8.4	7.9	1 89
B 866	Michigan Farmer Brand Cottonseed Meal........	Cass City............	7.2	41.1	10.1	7.3	2 00
B 895	Michigan Farmer Brand Cottonseed Meal........	Almont...............	7.1	42.1	8.0	7.7	2 00
B 899	Michigan Farmer Brand Cottonseed Meal........	Richmond............	13.2	41.0	7.9	9.7	2 09
B 907	Michigan Farmer Brand Cottonseed Meal........	Oxford...............	8.1	49.8	7.1	5.6	2 00
B 930	Michigan Farmer Brand Cottonseed Meal........	Bronson..............	7.8	39.6	6.7	9.2	1 90
B 941	Michigan Farmer Brand Cottonseed Meal........	Homer...............	8.0	39.9	6.2	12.6	1 90
B 1238	Michigan Farmer Brand Cottonseed Meal........	St. Joseph............	9.5	40.8	6 3	9.6	1 80
		Average...........	7.9	40.6	7.1	10.2	....
	F. W. Brode, Memphis, Tenn.						
		*G.	......	41.0	6.0	10.0	....
B 2	Owl Brand Cottonseed Meal.....................	Lakeview....... *F.	9.2	32.7	6.2	15.4	....
B 3	Owl Brand Cottonseed Meal.....................	Lakeview.............	7.7	34.4	5.7	13.7	....
B 22	Owl Brand Cottonseed Meal.....................	Owosso..............	8.8	33.9	6.3	14.4	$2 00
B 222	Owl Brand Cottonseed Meal.....................	Mason...............	8.2	34.8	5.7	14.3	2 00
B 131	Owl Brand Cottonseed Meal.....................	Owosso..............	9.1	33.6	6.2	14.5	....
B 836	Owl Brand Cottonseed Meal.....................	Croswell.............	8.7	37.1	6.1	12.8	38 00
B 837	Owl Brand Cottonseed Meal.....................	Sandusky............	8.4	36.7	5.8	13.1	38 00
B 852	Owl Brand Cottonseed Meal.....................	Clio.................	7.6	37 9	7.2	10.7	38 00
B 854	Owl Brand Cottonseed Meal.....................	Vassar..............	7.5	34.7	5.4	14.1	2 00
B 857	Owl Brand Cottonseed Meal.....................	Vassar..............	8.4	37.3	5.9	13.2	1 80
B 858	Owl Brand Cottonseed Meal.....................	Vassar..............	7 6	36.0	6.1	12.2	1 85
B 910	Owl Brand Cottonseed Meal.....................	Utica................	7.7	38.7	6.1	11.7	2 00
B 1032	Owl Brand Cottonseed Meal.....................	Traverse City.........	7.9	41.1	6.9	9.0	38 00
		Average...........	8.2	36.1	6.1	13.0	....
		*G.	......	38.6	6.0	10.0	....
B 707	Dove Brand Prime Cottonseed Meal.............	Iron Mountain.. *F.	8.1	29.8	5.7	18.1	$2 35
B 743	Dove Brand Prime Cottonseed Meal.............	Houghton............	7.0	36.1	8.2	12.7	2 25
		Average...........	7.6	33.0	7.0	15.4	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at.		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	The Buckeye Cotton-Oil Co., Cincinnati, Ohio.							
			*G.	......	38.6	6.0	12.0	....
B 699	Buckeye Prime Cottonseed Meal	Gladstone	*F.	7.7	40.3	7.8	12.2	$1 90
B 731	Buckeye Prime Cottonseed Meal	Ironwood		8.0	39.6	7.4	10.7	2 25
B 768	Buckeye Prime Cottonseed Meal	Marquette		8.2	37.8	7.4	11.8	1 85
B 1012	Buckeye Prime Cottonseed Meal	Fremont		8.4	41.9	7.5	9.1	39 00
		Average		8.1	39.9	7.5	11.0	....
	Chapin & Co., Hammond, Ind.							
			*G.	......	41.0	7.0	10.0	....
B 653	Green Diamond Brand Choice Cottonseed Meal	North Adams	*F.	9.2	45.0	7.7	7.7	$1 90
	S. P. Davis, Little Rock, Ark.							
			*G.	......	41.0	6.0	9.0	....
B 69	Good Luck Cottonseed Meal	Saginaw	*F.	7.0	40.9	8.3	10.3	$2 00
B 143	Good Luck Cottonseed Meal	Lansing		12.0	41.9	6.6	8.1	39 00
B 176	Good Luck Cottonseed Meal	Detroit		7.3	40.0	6.5	10.9	38 00
B 618	Good Luck Cottonseed Meal	Ypsilanti		6.7	42.6	6.8	8.3	1 90
B 637	Good Luck Cottonseed Meal	Monroe		8.5	38.6	6.9	12.1	1 85
		Average		8.3	40.8	7.0	9.9	....
			*G.	......	38.5	6.0	12.0	....
B 187	Veribest Cottonseed Meal	Detroit	*F.	6.6	39.6	6.9	11.0	$36 50
B 304	Veribest Cottonseed Meal	Detroit		7.2	38.6	6.9	12.2	2 00
B 384	Veribest Cottonseed Meal	Dowagiac		9.8	32.5	7.4	15.4	2 00
B 913	Veribest Cottonseed Meal	Mt. Clemens		10.1	38.5	6.8	11.6	1 90
		Average		8.4	37.3	7.0	12.6	....
	East St. Louis Cotton-Oil Co., National Stock Yds., Ill.							
			*G.	......	38.5	6.0	12.0	....
B 528	East St. Louis Cottonseed Meal	Zeeland	*F.	7.1	41.3	7.6	9.6	$38 00
B 600	East St. Louis Cottonseed Meal	Holland		7.6	41.5	7.2	9.1	37 00
B 641	East St. Louis Cottonseed Meal	Trenton		7.1	40.9	7.2	9.9	1 90
B 670	East St. Louis Cottonseed Meal	Adrian		7.1	35.0	6.9	13.1	1 95
B 885	East St. Louis Cottonseed Meal	Birmingham		7.0	39.7	6.6	11.0	1 90
B 1267	East St. Louis Cottonseed Meal	Paw Paw		6.7	39.2	7.0	11.4	1 95
B 1290	East St. Louis Cottonseed Meal	Battle Creek		6.8	40.1	6.7	10.1	38 00
		Average		7.1	39.7	7.0	10.6	....
			*G.	......	41.0	7.0	12.0	....
B 7	Illinois Brand Cottonseed Meal	Owosso	*F.	6.5	39.0	6.9	12.2	$2 00
B 20	Illinois Brand Cottonseed Meal	Owosso		6.8	40.2	7.3	10.2	2 00
B 53	Illinois Brand Cottonseed Meal	Saginaw		6.8	42.6	8.4	9.5	2 20
B 82	Illinois Brand Cottonseed Meal	Bay City		6.0	40.4	7.0	10.5	2 00
B 250	Illinois Brand Cottonseed Meal	Jackson		7.0	39.7	8.8	10.5	2 00
B 926	Illinois Brand Cottonseed Meal	Coldwater		6.9	41.6	6.6	9.2	2 00
B 191	Illinois Brand Cottonseed Meal	Detroit		6.7	39.6	7.9	11.4	37 00
B 399	Illinois Brand Cottonseed Meal	Kalamazoo		6.3	40.6	7.1	10.5	1 85
B 489	Illinois Brand Cottonseed Meal	Grandville		7.0	37.4	6.5	13.4	38 00
B 627	Illinois Brand Cottonseed Meal	Milan		7.6	40.3	8.1	9.1	1 85
B 631	Illinois Brand Cottonseed Meal	Dundee		7.4	38.1	7.1	12.2	1 85
B 657	Illinois Brand Cottonseed Meal	Hudson		7.3	40.8	8.0	9.3	1 85
B 674	Illinois Brand Cottonseed Meal	Morenci		6.9	40.3	7.4	10.5	1 90
B 675	Illinois Brand Cottonseed Meal	Morenci		6.4	35.7	8.0	12.8	1 90
B 1260	Illinois Brand Cottonseed Meal	Paw Paw		6.9	38.3	7.1	12.0	1 90
B 1315	Illinois Brand Cottonseed Meal	Albion		6.1	39.9	9.0	10.9	2 00
		Average		6.8	39.7	7.6	10.9	....
	Empire Cotton-Oil Co., Atlanta, Ga.							
			G*.	......	38.0	6.0	12.0	....
B 80	Gilt Edge Cottonseed Meal	Bay City	*F.	6.8	37.1	6.4	12.0	$40 00

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Feeders Supply Co., Kansas City, Mo.							
			*G.	......	41.0	6.0	10.0	....
B 110	Equity Brand Cottonseed Meal and Cake	Lansing	*F.	9.2	35.9	6.5	13.0	$32 00
B 121	Equity Brand Cottonseed Meal and Cake	Lansing		7.5	41.3	6.8	10.0	40 00
B 149	Equity Brand Cottonseed Meal and Cake	Howell		6.4	39.2	6.8	12.3	1 90
B 238	Equity Brand Cottonseed Meal and Cake	Jackson		6.7	40.5	8.2	10.1	1 85
B 269	Equity Brand Cottonseed Meal and Cake	Jackson		7.3	40.0	6.9	10.5	37 00
B 390	Equity Brand Cottonseed Meal and Cake	Dowagiac		7.8	38.1	7.2	12.9	2 00
B 396	Equity Brand Cottonseed Meal and Cake	Decatur		8.3	39.3	7.1	12.1	....
B 434	Equity Brand Cottonseed Meal and Cake	Grand Rapids		8.2	39.0	6.8	12.5	39 00
B 483	Equity Brand Cottonseed Meal and Cake	Grand Rapids		7.2	41.8	7.6	9.9	42 00
B 591	Equity Brand Cottonseed Meal and Cake	Reed City		7.0	41.0	7.0	9.8	45 00
B 611	Equity Brand Cottonseed Meal and Cake	Ann Arbor		9.1	33.9	6.3	14.3	1 85
B 612	Equity Brand Cottonseed Meal and Cake	Ann Arbor		9.3	33.1	5.9	15.5	1 85
B 629	Equity Brand Cottonseed Meal and Cake	Dundee		8.1	42.2	7.3	11.5	1 85
B 807	Equity Brand Cottonseed Meal and Cake	Flint		7.9	39.4	6.8	11.4	38 00
B 938	Equity Brand Cottonseed Meal and Cake	Union City		8.4	38.6	8.9	10.7	1 90
B 1023	Equity Brand Cottonseed Meal and Cake	Manistee		7.8	38.6	6.9	11.5	40 00
B 1312	Equity Brand Cottonseed Meal and Cake	Marshall		8.5	35.9	7.2	10.3	1 90
B 1318	Equity Brand Cottonseed Meal and Cake	Eaton Rapids		6.8	41.5	6.7	11.2	2 00
		Average		7.9	38.8	7.1	11.6	....
	Humphreys-Godwin Co., Memphis, Tenn.							
			*G.	......	41.0	5.0	10.0	....
B 1244	Bull Brand Cottonseed Meal	Coloma	*F.	7.0	41.6	6.8	7.8	$2 00
			*G.	......	36.0	5.0	15.0	....
B 451	Danish Brand Cottonseed Meal	Grand Rapids	*F.	9.2	36.4	6.1	13.8	38 00
B 480	Danish Brand Cottonseed Meal	Grand Rapids		8.1	35.3	6.0	14.4	42 00
B 492	Danish Brand Cottonseed Meal	Grandville		8.2	37.1	6.5	12.2	38 00
B 1044	Danish Brand Cottonseed Meal	Cadillac		7.4	37.1	6.0	11.8	42 50
		Average		8.2	36.5	6.2	13.1	....
			*G.	......	38.6	6.0	12.0	....
B 495	Dixie Brand Cottonseed Meal	Berlin	*F.	7.3	38.8	6.4	11.5	$38 00
B 1040	Dixie Brand Cottonseed Meal	Petoskey		7.9	35.0	7.7	13.2	38 00
		Average		7.6	36.9	7.1	12.4	....
	Imperial Cotto Milling Co., Memphis, Tenn.							
			*G.	......	41.0	8.0	9.0	....
B 444	Imperial Cotto	Grand Rapids	*F.	8.0	40.6	6.6	11.5	$39 00
B 526	Imperial Cotto	Zeeland		9.1	35.9	5.9	14.4	38 00
		Average		8.6	38.3	6.3	13.0	....
	Lainer Bros., Nashville, Tenn.							
			*G.	......	38.6	6.0	10.0	....
B 348	Jersey Brand Cottonseed Meal	Niles	*F.	8.0	39.6	6.0	13.1	$2 00
	W. C. Nothern, Little Rock, Ark.							
			*G.	......	41.0	6.0	10.0	....
B 418	Bee Brand Cottonseed Meal	Grand Rapids	*F.	9.1	41.8	6.4	10.1	40 00
B 590	Bee Brand Cottonseed Meal	Reed City		7.6	42.3	7.3	8.1	45 00
B 594	Bee Brand Cottonseed Meal	Big Rapids		7.6	43.3	7.5	7.1	38 00
B 616	Bee Brand Cottonseed Meal	Ypsilanti		8.3	41.1	6.3	9.5	1 90
		Average		8.2	42.1	6.9	8.7	....
			*G.	......	39.0	6.0	10.0	....
B 370	Butter Fly Cottonseed Meal and Cake	Niles	*F.	7.6	36.3	6.5	14.0	$2 00
B 587	Butter Fly Cottonseed Meal and Cake	Reed City		7.4	37.9	6.7	11.8	39 00
B 814	Butter Fly Cottonseed Meal and Cake	Davison		7.9	38.7	7.1	10.3	38 00
		Average		7.6	37.6	6.8	12.0	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—Continued.

Laboratory number.	Manufacturer and Trade Name.	Sampled at	Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Roberts Cotton Oil Co., Memphis, Tenn.						
		*G.	......	41.0	6.0	10.0	....
B 486	R Brand Cottonseed Meal......................	Grand Rapids... *F.	8.0	40.6	8.0	9.3	....
		*G.	......	38.6	6 0	10.0	....
B 504	Prime Cottonseed Meal........................	Coopersville.... *F	7.0	40.3	7.3	9.5	$35 00
B 1027	Prime Cottonseed Meal........................	Traverse City.........	7.4	37.4	5.6	12.8	36 00
		Average..........	7 2	38.9	6.5	11.2	....
	Sherman Oil Mills, Sherman, Texas.						
		*G.	......	43.0	6.0	9.0	....
B 274	Cottonseed Meal and Cake.....................	Jackson........ *F.	7.7	38.9	7.8	11.7	$38 00
B 889	Cottonseed Meal and Cake.....................	Rochester............	8.6	38.3	7.2	10.9	2 00
		Average..........	8.2	38.6	7.5	11.3	....
	Texas Cake & Linter Co., Dallas, Texas.						
		*G.	......	38.6	6.0	12.0	....
B 500	Interstate Cottonseed Meal.....................	Coopersville.... *F.	7.6	34.4	6.6	14.6	$35 00
		*G.	......	41.0	6.0	10.0	....
B 180	Sunset Brand Cottonseed Meal..................	Detroit......... *F.	8.2	35.9	6.3	14.5	37 00
B 459	Sunset Brand Cottonseed Meal..................	Grand Rapids.........	7.6	38.7	7.9	11.3	38 00
B 497	Sunset Brand Cottonseed Meal..................	Jenison..............	7.9	38.6	6.2	10.4	40 00
B 1022	Sunset Brand Cottonseed Meal..................	Holland..............	6 9	38.6	6.9	11.5	....
B 1018	Sunset Brand Cottonseed Meal..................	Holland..............	6.4	39.8	6.9	12.0	37 00
B 1006	Sunset Brand Cottonseed Meal..................	Zeeland..............	7.6	39.3	6.7	10.0	....
B 1002	Sunset Brand Cottonseed Meal..................	Holland..............	8.6	36.1	5.9	12.6	38 00
B 566	Sunset Brand Cottonseed Meal..................	Jamestown...........	6.4	44.2	7.8	7.5	37 00
B 573	Sunset Brand Cottonseed Meal..................	Zeeland..............	7.4	38.4	6.5	12.4	38 00
B 511	Sunset Brand Cottonseed Meal..................	Vriesland............	7.2	36.8	6.9	12.8	38 00
B 517	Sunset Brand Cottonseed Meal..................	Forest Grove.........	8.1	37.2	7.0	12.0	40 00
B 673	Sunset Brand Cottonseed Meal..................	Morenci..............	7.2	38.6	7.8	11.5	1 90
B 680	Sunset Brand Cottonseed Meal..................	Tecumseh............	6.9	39.0	7.8	11.1	1 95
B 906	Sunset Brand Cottonseed Meal..................	Oxford...............	8.4	37.7	6.1	13.5	2 00
B 1259	Sunset Brand Cottonseed Meal..................	Battle Creek..........	7.5	38.5	6.3	12.7	39 00
		Average..........	7.5	38.5	6.9	11.7	....
	Union Seed & Fertilizer Co., Argenta, Ark.						
		*G.	......	38.0	7.0	11.5	....
B 815	American Red Tag Cottonseed Meal............	Imlay City..... *F.	8.0	38.7	6.8	11.5	$38 00
	Wykes & Co., Grand Rapids, Mich.						
		*G.	......	41.0	7.0	10.0	....
B 413	Y X Cottonseed Meal..........................	Grand Rapids... *F.	7.5	42.9	6.9	7.7	$38 50
B 472	Y X Cottonseed Meal..........................	Grand Rapids.........	7.3	42.9	6.7	7.6	43 00
B 529	Y X Cottonseed Meal..........................	Zeeland..............	7.2	44.3	7.6	6.8	38 00
		Average..........	7.3	43.4	7.1	7.4	....
	COTTONSEED FEED.						
	Tennessee Fibre Co., Memphis, Tenn.						
		*G.	......	20.0	4.0	25.0	....
B 601	Creamo Brand Cottonseed Feed................	Mason......... *F.	7.9	24.8	4.6	21.0	....
	LINSEED MEAL.						
	American Linseed Co., Chicago, Ill.						
		*G.	......	34.0	6.0	9.0	....
B 931	O. P. Linseed Oil Meal.........................	Bronson........ *F.	8.5	33.3	7.7	7.9	$2 25
B 933	O. P. Linseed Oil Meal.........................	Bronson..............	9.0	33.4	6.4	8.2	2 25
		Average..........	8.8	33.4	7.1	8.1	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	American Milling Co., Peoria, Ill.							
			*G.	......	30.0	5.0	10.0	....
B 467	Ameo Linseed Meal	Grand Rapids	*F.	9.7	30.3	6.3	8.7	$42 00
B 523	Ameo Linseed Meal	Forest Grove		9.1	30.3	6.5	9.2	40 00
B 1011	Ameo Linseed Meal	Fremont		9.1	30.8	5.6	8.8	....
B 1045	Ameo Linseed Meal	Cadillac		9.7	30.3	6.4	8.4	42 50
		Average		9.4	30.4	6.2	8.8	....
	Archer Daniels Linseed Co., Minneapolis, Minn.							
			*G.	......	32.0	6.0	10.0	....
B 345	O. P. Ground Oil Cake	Niles	*F.	8.5	36.1	6.6	7.7	$2 15
B 368	O. P. Ground Oil Cake	Niles		8.1	33.9	6.9	8.2	2 15
B 410	O. P. Ground Oil Cake	Grand Rapids		9.0	34.8	6.5	8.1	42 00
		Average		8.5	34.9	6.7	8.0	....
	Chicago Heights Oil Mfg. Co., Chicago, Ill.							
			*G.	......	25.0	6.0	12.0	....
B 34	O. P. Laxo Cake Meal	Alma	*F.	9.6	27.9	5.7	9.1	$39 00
B 316	O. P. Laxo Cake Meal	Detroit		9.4	25.2	6.4	10.0	2 00
B 1016	O. P. Laxo Cake Meal	Fremont		9.9	24.6	6.3	3.6	....
		Average		9.6	25.9	6.1	7.6	....
	Hirst & Begley Linseed Co., Chicago, Ill.							
			*G.	......	34.0	6.0	9.0	....
B 419	Hirst & Begley O. P. Linseed Oil Meal	Grand Rapids	*F.	10.1	34.0	8.5	2.4	$45 00
B 508	Hirst & Begley O. P. Linseed Oil Meal	Coopersville		8.2	32.9	9.1	7.9	40 00
B 527	Hirst & Begley O. P. Linseed Oil Meal	Zeeland		8.7	32.8	11.6	7.8	42 00
B 559	Hirst & Begley O. P. Linseed Oil Meal	Muskegon		8.6	33.1	9.4	8.2	40 00
B 570	Hirst & Begley O. P. Linseed Oil Meal	Jamestown		8.9	33.4	9.6	7.7	41 00
		Average		8.9	33.2	9.6	7.9	....
	The Metzger Seed & Oil Co., Toledo, Ohio.							
			*G.	......	30.0	5.0	10.0	....
B 4	O. P. Oil Meal	Lakeview	*F.	8.1	33.6	6.8	7.9	....
B 27	O. P. Oil Meal	Mt. Pleasant		7.9	35.0	6.8	7.7	$40 00
B 52	O. P. Oil Meal	Saginaw		8.3	33.6	7.1	7.8	40 00
		Average		8.1	34.1	6.9	7.8	....
	Midland Linseed Products Co., Minneapolis, Minn.							
			*G.	......	32.0	5.0	9.5	....
B 374	O. P. Ground Linseed Meal	Niles	*F.	9.9	34.4	5.4	7.6	$2 15
B 630	O. P. Ground Linseed Meal	Dundee		8.5	34.3	8.5	7.4	2 00
		Average		9.2	34.4	7.0	7.5	....
	Milwaukee Linseed Oil Co., Milwaukee, Wis.							
			*G.	......	32.0	5.0	8.0	....
B 92	Ground Linseed Cake	Bay City	*F.	8.4	35.4	6.3	7.4	$2 10
B 463	Ground Linseed Cake	Grand Rapids		10.0	35.1	7.1	7.7	44 00
B 512	Ground Linseed Cake	Vriesland		9.1	33.8	6.7	8.5	42 00
		Average		9.2	34.8	6.7	7.9	....
			*G.	......	32.0	5.0	8.0	....
B 567	Milwaukee Linseed Meal	Jamestown	*F.	10 0	33.8	6.9	7.9	$41 00
	Minnesota Linseed Co., Minneapolis, Minn.							
			*G.	......	34.0	5.0	8.0	....
B 703	Ground Linseed Cake	Escanaba	*F.	8.4	34.7	6.1	7.7	$2 10

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—Continued.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Northern Linseed Oil Co., Minneapolis, Minn.							
			*G.	.....	33.0	6.0	9.0	....
B 385	O. P. Ground Linseed Cake	Dowagiac	*F.	9.5	33.1	6.4	8.9	$2 25
B 535	O. P. Ground Linseed Cake	Spring Lake		9.2	33.3	6.4	8.3	46 00
		Average		9.4	33.2	6.4	8.6	....
	The Sherwin Williams Co., Cleveland, Ohio.							
			*G.	.....	33.0	6.0	8.0	....
B 932	Sherwin Williams Linseed Oil Meal	Bronson	*F.	9.0	34.5	6.7	7.9	$2 25
	Spencer Kellog & Sons, Buffalo, N. Y.							
			*G.	.....	33.0	5.0	10.0	....
B 104	Pure O. P. Oil Meal	Benton Harbor	*F.	8.8	34.6	5.7	7.4	$2 25
B 346	Pure O. P. Oil Meal	Niles		9.3	35.1	6.2	8.0	2 15
B 533	Pure O. P. Oil Meal	Grand Haven		9.3	35.2	5.9	8.2	42 00
B 719	Pure O. P. Oil Meal	Iron River		8.1	35.4	6.0	7.9	2 50
B 732	Pure O. P. Oil Meal	Ironwood		7.6	34.3	7.5	7.9	2 50
B 739	Pure O. P. Oil Meal	Ontonagon		8.9	33.9	5.8	7.8	2 50
		Average		8.7	34.8	6.2	7.9	....
	Toledo Seed & Oil Co., Toledo, Ohio.							
			*G.	.....	30.0	5.0	10.0	....
B 13	O. P. Oil Meal	Owosso	*F.	8.5	30.1	6.8	8.1	$2 25
B 54	O. P. Oil Meal	Saginaw		8.2	32.7	6.3	8.0	2 25
B 78	O. P. Oil Meal	Bay City		7.7	30.2	5.9	8.6	42 00
B 159	O. P. Oil Meal	Howell		9.4	31.8	6.9	7.6	2 25
B 184	O. P. Oil Meal	Detroit		8.5	30.4	6.0	8.8	38 00
B 257	O. P. Oil Meal	Jackson		7.9	29.6	6.3	8.6	2 00
B 279	O. P. Oil Meal	Detroit		8.7	30.0	6.2	9.0	1 95
B 303	O. P. Oil Meal	Detroit		8.3	29.8	6.2	9.1	1 90
B 804	O. P. Oil Meal	Perry		8.6	30.0	6.1	8.7	40 00
B 809	O. P. Oil Meal	Flint		9.8	29.2	5.9	8.8	42 00
		Average		8.6	30.4	6.3	8.5	....
	FLAX SEED MEAL.							
	Bromfield & Colvin, Bay City, Mich.							
			*G.	.....	.....	.....	.....	....
B 83	Flax Seed Meal	Bay City	*F.	5.1	24.3	27.9	5.3	$5 00
	Chatfield Milling & Grain Co., Bay City, Mich.							
B 77	Flax Seed Meal	Bay City		5.4	21.4	39.4	5.2	$6 00
	Mayflower Mills, Fort Wayne, Ind.							
			*G.	.....	.....	.....	.....	....
B 55	Flax Seed Meal	Saginaw	*F.	4.1	23.3	29.6	6.4	$5 50
	Wenonah Mills Co., Bay City, Mich.							
B 93	Flax Seed Meal	Bay City		9.9	23.6	30.8	6.6	$4 50

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	DISTILLERS' DRIED GRAINS.							
	Chiefly from Corn.							
	Ajax Milling & Feed Co., New York.							
			*G.	......	30.0	10.0	14.0	....
B 25	Ajax Flakes	Mt. Pleasant	*F.	5.7	30.2	9.2	17.3	$34 00
B 169	Ajax Flakes	Howell		6.3	31.2	10.3	11.7	1 80
B 221	Ajax Flakes	Mason		7.9	33.8	10.3	11.1	1 80
B 243	Ajax Flakes	Jackson		7.1	34.1	10.1	11.6	1 75
B 810	Ajax Flakes	Flint		6.1	30.4	9.3	13.5	35 00
		Average		6.6	31.9	9.8	13.0	......
	Continental Cereal Co., Peoria, Ill.							
			*G.	......	29.0	10.0	10.0	....
B 228	Continental Gluten Feed	Jackson	*F.	7.7	25.9	7.9	7.0	$1 75
B 343	Continental Gluten Feed	Buchanan		7.4	27.6	8.2	8.5	1 75
B 455	Continental Gluten Feed	Grand Rapids		9.1	26.0	7.9	7.8	33 00
B 499	Continental Gluten Feed	Coopersville		7.1	27.1	8.3	7.5	32 00
B 624	Continental Gluten Feed	Ypsilanti		9.6	27.0	7.4	5.2	1 50
		Average		8.2	26.7	7.9	7.2	....
	Dewey Bros. Co., Blanchester, O.							
			*G.	......	30.0	10.0	13.0	....
B 251	Eagle 3D Dried Grains	Jackson	*F.	7.8	30.7	11.5	8.1	$1 75
B 1297	Eagle 3D Dried Grains	Battle Creek		5.8	32.6	14.0	12.9	1 75
		Average		6.8	31.7	12.8	10.5	....
	Hammond Distilling Co., Hammond, Ind.							
			*G.	......	30.0	10.0	......	....
B 174	Dried Distillers' Grains	Detroit	*F.	5.8	30.7	10.5	10.1	$32 00
B 273	Dried Distillers' Grains	Jackson		6.6	32.9	11.0	9.6	31 00
		Average		6.2	31.8	10.8	9.9	....
	Larrowe Milling Co., Detroit, Mich.							
			*G.	......	26.0	7.0	9.0	....
B 880	Brownie Grains, Steam Dried Distillers' Grains	Birmingham	*F.	9.7	29.1	12.1	9.0	$1 65
	DISTILLERS' DRIED GRAINS.							
	Chiefly from Rye.							
	Interstate Feed Association, Detroit, Mich.							
			*G.	......	16.0	7.0	12.0	....
B 779	Interstate Dairy & Hog Feed	Bay City	*F.	7.2	13.4	5.7	15.8	$1 40
B 780	Interstate Dairy & Hog Feed	Lapeer		10.6	14.1	5.2	13.0	25 00
		Average		8.9	13.8	5.5	14.4	....
	BREWERS' DRIED GRAINS.							
	J. E. Bartlett & Co., Jackson, Mich.							
			*G.	......	19.0	6.0	20.0	....
B 1291	Bartlett's Malt Sugar Grain & Feed	Battle Creek	*F.	7.9	18.7	6.3	18.3	$25 00
	Farmers Feed Co., New York.							
			*G.	......	27.2	6.3	16.2	....
B 884	Bull Brand Dried Brewers Grains	Birmingham	*F.	7.7	27.5	6.1	13.2	$1 50
	The Fleischmann Co., Chicago, Ill.							
			*G.	......	19.0	7.0	19.0	....
B 470	Fleischmann's Dried Grains	Grand Rapids	*F.	7.5	18.1	6.7	17.9	$27 00

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Pricer per ton or cwt.
	Hottelet Co., Milwaukee, Wis.							
			*G.	......	25.0	5.0	14.0	....
B 452	Holstein Brewers' Dried Grains................	Grand Rapids...	*F.	8.1	26.8	5.6	14.2	$29 00
	Kellogg-Toasted Corn Flake Co., Battle Creek, Mich.							
			*G.	......	25.1	5.1	12.8	....
B 267	Dried Brewers' Grains........................	Jackson........	*F.	5.8	34.9	5.3	9.8	$27 00
B 465	Dried Brewers' Grains........................	Grand Rapids.........		5.9	32.7	5.2	10.1	30 00
B 1272	Dried Brewers' Grains........................	Battle Creek..........		6.4	32.7	4.8	9.4	25 00
		Average...........		6.0	33.4	5.1	9.8	....
	K. & E. Neumond, St. Louis, Mo.							
			*G.	......	24.0	6.0	13.0	....
B 414	Goldnes Kalb Dried Brewers' Grains............	Grand Rapids...	*F.	6.8	23.9	4.9	15.4	$29 00
	CORN GLUTEN FEED.							
	American Maize Products Co., New York, N. Y.							
			*G.	......	24.0	1.5	8.5	....
B 613	Cream of Corn Gluten Feed....................	Ann Arbor......	*F.	9.8	25 1	1.7	6.4	$1 45
B 628	Cream of Corn Gluten Feed....................	Dundee..............		10.2	24.7	1.8	6.5	1 50
B 808	Cream of Corn Gluten Feed....................	Flint.		9.5	25.6	2.4	6.5	31 00
B 813	Cream of Corn Gluten Feed....................	Davison.............		7.7	24.7	1.2	6.6	1 60
		Average...........		9.3	25.0	1.8	6.5	....
	J. E. Bartlett Co., Jackson, Mich.							
			*G.	......	31.0	12.0	13.0	....
B 271	National Gluten Feed.........................	Jackson........	*F.	5.5	34.3	7.2	13.2	$31 00
	Corn Products Refining Co., New York, N. Y.							
			*G.	......	23.0	1.0	8.5	....
B 12	Buffalo Corn Gluten Feed......................	Owosso.........	*F.	9.4	27.6	2.4	6.3	$1 65
B 46	Buffalo Corn Gluten Feed......................	Saginaw.............		10.2	28.1	2.3	7.6	35 00
B 89	Buffalo Corn Gluten Feed......................	Bay City............		6.4	29.6	3.1	6.5	2 00
B 105	Buffalo Corn Gluten Feed......................	Benton Harbor........		8.3	29.1	1.4	7.0	1 60
B 125	Buffalo Corn Gluten Feed......................	Lansing.............		8.5	26.1	1.7	8.3	32 00
B 247	Buffalo Corn Gluten Feed......................	Jackson.............		8.5	28.1	1.6	7.0	1 60
B 421	Buffalo Corn Gluten Feed......................	Grand Rapids.........		10.5	30.6	2.2	5.8	37 00
		Average...........		8.8	28.5	2.1	6.9	....
	Douglas Co., Cedar Rapids, Ia.							
			*G.	......	23.0	1.0	8.0	....
B 6	Douglas Corn Gluten Feed.....................	Owosso.........	*F.	7.9	26.2	3.3	6.4	$1 55
B 19	Douglas Corn Gluten Feed.....................	Owosso..............		9.3	24.2	2.7	7.3	1 50
B 31	Douglas Corn Gluten Feed.....................	Mt. Pleasant..........		8.5	24.4	3.1	7.6	30 00
B 79	Douglas Corn Gluten Feed.....................	Bay City............		8.9	25.1	3.8	5.9	32 00
B 216	Douglas Corn Gluten Feed.....................	Mason...............		10.1	24.9	2.6	6.7	1 60
B 260	Douglas Corn Gluten Feed.....................	Jackson.............		12.4	24.4	3.2	7.4	30 00
B 411	Douglas Corn Gluten Feed.....................	Grand Rapids.........		11.4	23.6	3.2	6.9	32 00
		Average...........		9.8	24.7	3.1	6.9	....
	Huron Milling Co., Harbor Beach, Mich.							
			*G.	......	22.0	3.0	8.0	....
B 685	Jenks Corn Gluten Feed.......................	Alpena.........	*F.	7.4	23.4	1.7	8.2	$1 70
B 823	Jenks Corn Gluten Feed.......................	Port Huron...........		8.1	24.3	1.8	7.4	1 70
B 844	Jenks Corn Gluten Feed.......................	Harbor Beach.........		10.2	24.7	3.3	7.4	1 35
		Average...........		8.6	24.1	2.3	7.7	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—Continued.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Interstate Feed Association, Detroit, Mich.							
			*G.	......	21.9	7.3	15.6	....
B 572	Interstate Gluten Feed	Zeeland	*F.	7.9	20.4	7.9	19.4	$31 00
B 615	Interstate Gluten Feed	Ann Arbor		9.8	22.4	7.1	13.5	1 55
		Average		8.9	21.4	7.5	16.5	....
	CORN GLUTEN MEAL.							
	Corn Products Refining Co., New York, N. Y.							
			*G.	......	40.0	1.5	4.0	....
B 1010	Diamond Corn Gluten Meal	Fremont	*F.	9.7	45.3	1.3	1.4	....
B 1249	Diamond Corn Gluten Meal	Paw Paw		10.0	44.4	1.5	1.4	$2 00
B 1292	Diamond Corn Gluten Meal	Battle Creek		6.7	46.5	0.6	1.6	39 00
		Average		13.2	45.4	1.1	1.5	....
	HOMINY FEEDS.							
	Cereal Mills Co., Wausau, Wis.							
			*G.	......	11.3	8.5	4.0	....
B 717	Cemco Hominy Feed	Crystal Falls	*F.	15.9	9.9	7.4	3.0	$2 00
B 720	Cemco Hominy Feed	Iron River		9.2	9.9	7.2	3.6	1 75
		Average		12.6	9.9	7.3	3.3	....
	Evans Milling Co., Indianapolis, Ind.							
			*G.	......	10.0	7.5	7.0	....
B 268	Evans' Hominy Feed	Jackson	*F.	10.1	10.1	7.1	3.6	$30 00
B 671	Evans' Hominy Feed	Morenci		9.4	10.0	6.4	6.1	1 50
B 873	Evans' Hominy Feed	Pontiac		10.6	10.4	6.3	5.0	1 55
		Average		10.0	10.2	6.6	4.9	....
	U. S. Frumentum Co., Detroit, Mich.							
			*G.	......	9.5	7.3	7.0	....
B 917	Frumentum Hominy Feed	Detroit	*F.	10.2	9.6	7.7	4.3	$27 50
	Chas. A. Krause Milling Co., Milwaukee, Wis.							
			*G.	......	10.0	6.0	5.0	....
B 160	Badger Hominy Feed	Howell	*F.	10.3	11.0	5.9	3.8	$1 40
B 518	Badger Hominy Feed	Forest Grove		8.8	11.8	6.8	4.5	32 00
B 568	Badger Hominy Feed	Jamestown		10.0	10.8	6.1	4.8	32 00
B 668	Badger Hominy Feed	Adrian		9.7	10.3	8.0	4.0	30 00
		Average		9.7	11.0	6.7	4.3	....
	CORN FEED MEAL.							
	Beck Cereal Co., Detroit, Mich.							
			*G.	......	......	......	......	....
B 281	Coarse Meal	Detroit	*F.	11.2	9.1	4.6	2.8	$1 45
	Ferdinand Becker, Grand Rapids, Mich.							
			*G.	......	7.7	3.7	1.5	....
B 462	Feed Corn Meal	Grand Rapids	*F.	15.5	8.2	2.0	2.5	$34 00
	Clinton Sugar Refining Co., Clinton, Ia.							
			*G.	......	20.0	7.0	12.0	....
B 666	Clinton Corn Germ Meal	Adrian	*F.	8.5	21.3	10.2	8.6	$30 00

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory Number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Cheboygan Flour Mill Co., Cheboygan, Mich.							
B 689	Corn Germ Meal	Cheboygan	*G.	......	9.0	5.0	4.0	....
			*F.	15.2	10.8	5.4	4.8	$1 70
	Commercial Milling Co., Detroit, Mich.							
B 301	Corn Meal	Detroit	*G.	......	......	......	......	....
			*F.	12.1	9.0	3.8	2.4	$1 55
B 892	Henkels Coarse Feed Corn Meal	Rochester	*G.	......	8.5	......	2.0	....
			*F.	12.9	7.7	2.6	1.1	2 00
	Darrah Milling Co., Big Rapids, Mich.							
B 593	Unbolted Corn Meal	Big Rapids	*G.	......	8.8	2.7	4.8	....
			*F.	12.3	8.9	4.5	2.3	$35 00
	Grand Rapids Grain & Milling Co., Grand Rapids, Mich.							
B 440	Coarse Corn Meal	Grand Rapids	*G.	......	......	......	......	....
			*F.	9.9	10.4	3.7	9.5	$31 00
	Hankey Milling Co., Petoskey, Mich.							
B 1038	Feed Meal	Petoskey	*G.	......	9.7	5.3	3.4	....
			*F.	12.8	8.6	3.3	2.3	$33 00
	Henderson Milling Co., Grand Rapids, Mich.							
B 437	Coarse Corn Meal	Grand Rapids	*G.	......	8.8	4.2	1.3	....
			*F.	13.8	7.4	2.4	1.2	$30 50
	A. Hyde & Son, Grand Rapids, Mich.							
B 487	Coarse Corn Meal	Grand Rapids	*G.	......	8.8	2.9	2.0	....
			*F.	15.8	7.6	......	1.6	$32 00
	King Milling Co., Lowell, Mich.							
B 576	King Corn Meal	Lowell	*G.	......	8.9	6.7	2.9	....
			*F.	10.2	9.1	5.8	3.4	$32 00
	Saginaw Milling Co., Saginaw, Mich.							
B 45	Coarse Meal	Saginaw	*G.	......	......	......	......	....
			*F.	11.3	9.0	3.0	2.2	$31 00
B 208	Corn Meal	Highland	*G.	......	......	......	......	....
			*F.	8.9	10.7	6.3	3.5	....
	Scheuren & Mok, Detroit, Mich.							
B 313	Fine Cracked Corn	Detroit	*G.	......	......	......	......	....
			*F.	16.2	8.2	......	1.2	$1 60
	Wolcott Grain Co., Saginaw, Mich.							
B 68	No. 1 Coarse	Saginaw	*G.	......	......	......	......	....
			*F.	11.0	9.5	3.5	4.0	$1 70

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	ANIMAL BY PRODUCTS.							
	Ann Arbor Abattoir Co., Ann Arbor, Mich.							
			*G.	......	40.0	......	......	....
B 776	Three A Blood & Bone Meal	Ann Arbor	*F.	6.2	42.4	7.7	1.8	$35 00
	Armour & Co., Chicago, Ill.							
			*G.	......	60.0	6.0	2.0	....
B 367	Armour Meat Meal	Niles	*F.	7.7	67.6	10.5	1.3	$2 50
B 501	Armour Meat Meal	Coopersville		7.5	64.4	10.1	2.1	60 00
		Average		7.6	66.0	10.3	1.7	....
	Darling & Co., Chicago, Ill.							
			*G.	......	60.0	0.5	3.0	....
B 349	Darling's 60% Digester Tankage	Niles	*F.	8.7	60.1	6.9	2.0	$2 60
B 617	Darling's 60% Digester Tankage	Ypsilanti		10.3	60.6	6.3	2.3	2 75
		Average		9.5	60.4	6.6	2.2	....
			*G.	......	20.0	2.0	3.0	....
B 898	Darling's Granulated Bone	Armada	*F.	6.7	25.3	2.7	0.7	$2 75
			*G.	......	55.0	0.5	3.0	....
B 49	Darling's High Protein Meat Scraps	Saginaw	*F.	6.1	57.5	8.0	2.6	$62 00
B 108	Darling's High Protein Meat Scraps	Benton Harbor		6.3	57.3	8.4	2.4	3 25
B 142	Darling's High Protein Meat Scraps	Lansing		6.6	56.8	8.1	2.8	3 00
B 248	Darling's High Protein Meat Scraps	Jackson		7.3	55.6	7.7	2.8	2 85
B 417	Darling's High Protein Meat Scraps	Grand Rapids		7.1	53.9	8.1	3.3	70 00
B 828	Darling's High Protein Meat Scraps	Port Huron		7.6	54.3	8.0	2.7	3 10
		Average		6.8	55.9	6.1	2.8	....
			*G.	......	45.0	0.5	3.0	....
B 50	Darling's Standard Meat Scraps	Saginaw	*F.	7.1	52.3	6.8	2.9	$60 00
B 145	Darling's Standard Meat Scraps	Lansing		7.6	49.6	5.6	4.3	2 79
		Average		7.4	51.0	6.2	3.6	....
	Hales & Edwards, Chicago, Ill.							
			*G.	......	13.0	4.0	8.0	....
B 141	Red Comb Meat Scraps	Lansing	*F.	9.1	16.7	4.7	8.6	$2 05
	E. Rauh & Sons Animal Feed Co., Indianapolis, Ind.							
			*G.	......	80.0	......	......	....
B 643	Rauh's Meat Flakes	Trenton	*F.	8.1	80.9	10.1	0.4	$3 75
	Scheuren & Mok, Detroit, Mich.							
			*G.	......	45.0	10.0	......	....
B 310	Ground Meat Scraps	Detroit	*F.	6.6	49.1	10.8	2.2	$3 00
	Swift & Co., Chicago, Ill.							
			*G.	......	46.0	10.0	6.0	....
B 57	Swift's Pure Meat Meal	Saginaw	*F.	6.5	52.2	9.4	0.8	$3 20
			*G.	......	......	......	......	....
B 87	Swift's Pure Beef Meal	Bay City	*F.	5.3	48.6	5.6	1.5	3 00
			*G.	......	50.0	8.0	3.0	....
B 126	Swift's Meat Scraps	Lansing	*F.	6.1	55.9	10.4	2.7	55 00
B 422	Swift's Meat Scraps	Grand Rapids		6.5	53.8	11.5	1.8	60 00
		Average		6.3	54.9	11.0	2.3	....
B 122	Swift's Pure Digester Tankage	Lansing	*G.	......	60.0	6.0	3.0	....
			*F.	5.6	61.8	6.6	1.3	$55 00
B 347	Swift's Pure Digester Tankage	Niles		6.4	60.4	6.5	2.0	2 60
B 632	Swift's Pure Digester Tankage	Dundee		7.9	61.9	6.2	1.3	2 75
		Average		6.6	61.4	6.4	1.5	....
	Thoman Milling Co., Lansing, Mich.							
			*G.	......	56.0	......	......	....
B 656	Thoman Milling Co., Digester Tankage	North Adams	*F.	7.3	40.8	8.0	9.3	$2 40

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Chicago Feed & Fertilizer Co., Chicago, Ill.							
			*G.	......	60.0	6.0	3.0	....
B 9	Magic Brand Digester Tankage................	Owosso.........	*F.	8.4	61.9	5.2	2.2	$2 60
	Wuichet Fertilizer Co., Dayton, Ohio.							
			*G.	......	50.0	11.0	1.0	....
B 461	Beef Scraps..................................	Grand Rapids...	*F.	8.4	67.6	14.5	0.9	$65 00
	ALFALFA MEAL.							
	Albert Dickinson & Co., Chicago, Ill.							
			*G.	......	12.0	1.0	35.0	....
B 548	Alfalfa Meal.................................	Muskegon Hts..	*F.	9.4	12 6	1.5	31.9	$23 00
B 829	Alfalfa Meal.................................	Port Huron...........		7.0	14.6	1.6	26.6	1 80
		Average...........		8.2	13.6	1.6	29.3	....
	Hale & Edwards, Chicago, Ill.							
			*G.	......	13.5	1.0	30.0	....
B 226	Red Comb Alfalfa Meal.......................	Jackson........	*F.	8.5	13.2	1.7	32.2	$1 40
B 412	Red Comb Alfalfa Meal.......................	Grand Rapids.........		7.7	13.9	1.3	31.6	28 00
		Average...........		8.1	13.6	1.5	31.3	....
	Chas. A. Krause Milling Co., Milwaukee, Wis.							
			*G.	......	14.0	1.0	30.0	....
B 464	Alfalfa Meal.................................	Grand Rapids...	*F.	7.3	17.3	1.4	29.1	$50 00
	Omaha Alfalfa Milling Co., Omaha, Nebraska.							
			*G.	......	12.0	1.0	30.0	....
B 73	Alfalfa Meal.................................	Saginaw........	*F.	6.7	16.7	1.1	29.9	$1 75
B 1024	Alfalfa Meal.................................	Manistee.............		8.4	13.9	1.4	29.4	....
B 1028	Alfalfa Meal.................................	Traverse City.........		8.8	13.9	1.5	29.9	31 00
		Average...........		8.0	14.8	1.3	29.7	....
	Prairie State Milling Co., Peoria, Ill.							
			*G.	......	10.0	0.5	26.0	....
B 115	Greenfield Brand Alfalfa Meal & Molasses........	Lansing........	*F.	7.5	12.8	0.5	18.0	$1 40
	CALF MEALS.							
	American Milling Co., Peoria, Ill.							
			*G.	......	20.0	4.0	3.0	....
B 903	Sucrene Calf Meal............................	Utica..........	*F.	10.4	19.3	3.1	3.3	$3 20
B 1017	Sucrene Calf Meal............................	Fremont.............		10.6	18.8	3.4	10.5	72 00
B 1213	Sucrene Calf Meal............................	Kalamazoo...........		8.9	20.6	3.7	8.5	3 60
		Average...........		10.0	19.6	3.4	7.4	....
	Blatchfords Calf Meal Factory, Waukegan, Ill.							
			*G.	......	24.0	5.0	6.8	....
B 10	Blatchfords Quality Calf Meal..................	Owosso.........	*F.	9.2	25.7	5.2	6.1	$3 50
B 24	Blatchfords Quality Calf Meal..................	Mt. Pleasant..........		8.3	25.0	6.5	7.9	3 50
B 36	Blatchfords Quality Calf Meal..................	Alma................		9.0	24.5	5.1	6.9	4 00
B 51	Blatchfords Quality Calf Meal..................	Saginaw..............		8.7	24.6	5.1	6.2	58 00
B 84	Blatchfords Quality Calf Meal..................	Bay City............		7.7	25.3	5.1	5.8	3 50
B 88	Blatchfords Quality Calf Meal..................	Bay City............		7.6	26.6	5.6	6.7	4 00
B 116	Blatchfords Quality Calf Meal..................	Lansing..............		9.4	24.2	6.6	6.2	3 50
		Average...........		8.6	25.1	5.6	6.5	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—Continued.

Laboratory number.	Manufacturer and Trade Name.	Sampled at	Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Hales & Edwards, Chicago, Ill.						
		*G.	......	25.0	5.0	6.0	....
B 1037	Red Horn Calf Meal	Charlevoix *F.	11.0	24.5	5.7	1.4	$80 00
	J. C. Martin, Mineral Point, Wis.						
		*G.	......	26.0	6.0	6.0	....
B 358	Martin's Calf Meal	Niles *F.	9.0	24.7	7.7	5.7	$3 50
B 750	Martin's Calf Meal	Houghton	9.2	24.8	7.5	5.6	4 00
B 940	Martin's Calf Meal	Union City	10.1	25.0	6.0	5.1	4 00
B 1033	Martin's Calf Meal	Traverse City	9.8	24.0	7.4	5.2	60 00
		Average	9.5	24.6	7.2	5.4	....
	Quaker Oats Co., Chicago, Ill.						
		*G.	......	18.0	8.0	4.0	....
B 163	Schumacher Calf Meal	Howell *F.	7.5	18.7	8.4	2.7	$3 20
	Ryde & Co., Chicago, Ill.						
		*G.	......	25.0	5.0	6.0	....
B 5	Ryde's Cream Calf Meal	Owosso *F.	9.1	25.2	5.6	5.0	$3 50
B 81	Ryde's Cream Calf Meal	Bay City	8.5	25.5	5.5	6.6	60 00
B 106	Ryde's Cream Calf Meal	Benton Harbor	8.9	24.1	5.4	6.0	3 60
B 124	Ryde's Cream Calf Meal	Lansing	9.9	24.0	5.2	6.5	55 00
		Average	9.1	24.7	5.4	6.3	....
	F. I. Williams & Son, North Adams, Mich.						
		*G.	......	13.5	2.0	6.2	....
B 649	William's Calf Meal	North Adams *F.	7.3	14.4	1.9	2.0	$2 50
	HOG MEALS.						
	American Milling Co., Peoria, Ill.						
		*G.	......	16.0	6.0	10.0	....
B 663	Sucrene Hog Meal	Adrian *F.	14.4	19.1	4.4	7.4	$32 00
B 912	Sucrene Hog Meal	Mt. Clemens	11.8	16.3	7.4	8.2	1 70
		Average	13.1	17.7	5.9	7.8	....
	Blatchfords Calf Meal Factory, Waukegan, Ill.						
		*G.	......	18.0	5.0	7.0	....
B 48	Blatchford's Pig Meal	Saginaw *F.	8.0	19.3	4.9	6.3	$58 00
B 582	Blatchford's Pig Meal	Greenville	9.7	19.7	4.2	7.0	80 00
B 694	Blatchford's Pig Meal	Cheboygan	10.0	18.4	4.7	6.8	3 50
B 812	Blatchford's Pig Meal	Flint	9.6	18.2	4.0	6.8	3 00
B 875	Blatchford's Pig Meal	Pontiac	8.2	18.5	4.4	6.8	3 75
B 928	Blatchford's Pig Meal	Coldwater	9.9	19.6	4.3	5.6	3 50
		Average	9.2	19.0	4.4	6.6	....
	Corn Products Refining Co., New York, N. Y.						
		*G.	......	18.0	7.0	13.0	....
B 56	Diamond Hog Meal	Saginaw *F.	7.5	24.1	7.7	8.6	$1 80
B 357	Diamond Hog Meal	Niles	8.3	24.9	8.3	8.6	1 60
		Average	7.9	24.5	8.0	8.6	....
	Quaker Oats Co., Chicago, Ill.						
		*G.	......	18.0	4.5	10.0	....
B 276	Barley Feed	Jackson *F.	6.8	19.8	4.0	11.1	$26 00
B 1309	Barley Feed	Battle Creek	4.8	24.3	5.7	11.5	....
		Average	5.8	22.1	4.9	11.3	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—Continued.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	DAIRY FEEDS.							
	American Milling Co., Peoria, Ill.							
			*G.	......	10.0	3.5	12.0	....
B 154	Amco Fat Maker	Howell	*F.	9.1	10.7	3.5	8.8	$1 35
B 372	Amco Fat Maker	Niles		7.2	10.3	3.8	10.4	1 45
B 640	Amco Fat Maker	Monroe		11.2	11.3	4.5	9.8	25 00
B 803	Amco Fat Maker	Perry		8.6	11.4	5.0	12.5	26 50
		Average		9.0	10.9	4.2	10.4	....
			*G.	......	16.5	3.5	12.0	....
B 11	Sucrene Dairy Feed	Owosso	*F.	6.8	16.6	4.5	20.0	$1 20
B 136	Sucrene Dairy Feed	Lansing		8.5	18.1	4.8	12.6	26 00
B 460	Sucrene Dairy Feed	Grand Rapids		9.4	15.4	6.0	13.8	....
B 491	Sucrene Dairy Feed	Grandville		10.8	19.4	6.5	12.1	28.00
B 510	Sucrene Dairy Feed	Nunica		9.0	17.4	4.2	7.1	28 00
B 524	Sucrene Dairy Feed	Zeeland		10.2	16.1	5.4	12.1	27 00
B 802	Sucrene Dairy Feed	Perry		8.5	17.8	5.5	14.0	26 50
B1298	Sucrene Dairy Feed	Battle Creek		8.7	18.3	6.6	9.5	33 00
		Average		9.0	17.4	5.4	12.7	....
	Arcady Farms Milling Co., Chicago, Ill.							
			*G.	......	16.0	3.5	15.0	....
B 21	Arcady Dairy Feed	Owosso	*F.	10.7	19.0	3.8	13.6	$1 35
B 103	Arcady Dairy Feed	Benton Harbor		9.2	16.4	4.3	12.8	1 50
B 229	Arcady Dairy Feed	Jackson		10.2	14.4	3.9	12.4	1 45
B 468	Arcady Dairy Feed	Grand Rapids		9.4	16.0	4.3	12.7	28 00
		Average		9.9	14.5	4.1	12.9	....
			*G.	......	18.0	3.5	15.0	....
B 109	Arcady Certified Dairy Feed	Lansing	*F.	8.1	24.2	3.6	15.4	$1 40
B 320	Arcady Certified Dairy Feed	Detroit		7.9	16.5	3.5	13.0	1 35
B 503	Arcady Certified Dairy Feed	Coopersville		8.8	16.6	4.6	14.7	26 00
		Average		8.3	19.1	3.9	14.4	....
	J. J. Badenoch Co., Chicago, Ill.							
			*G.	......	10.0	0.5	25.0	....
B 1257	Kumboss Dairy Feed	Paw Paw	*F.	10.9	13.2	0.7	18.0	$1 50
	Blatchfords Calf Meal Factory, Waukegan, Ill.							
			*G.	......	17.5	5.0	18.0	....
B 765	Blatchford's Dairy Meal with Alfalfa	Marquette	*F.	9.1	19.6	5.0	13.3	$1 80
	Bad Axe Grain Co., Bad Axe, Mich.							
			*G.	......	10.8	2.9	19.2	....
B 868	Molasses Feed	Bad Axe	*F.	8.2	11.2	2.5	15.3	$1 10
B 901	Molasses Feed	St. Clair		9.1	18.8	3.0	15.5	1 65
		Average		8.7	15.0	2.8	15.4	....
	Chapin & Co., Hammond, Ind.							
			*G.	......	26.0	5.5	11.0	....
B 220	Unicorn Dairy Ration	Mason	*F.	7.2	28.0	6.2	10.6	$1 80
B 168	Unicorn Dairy Ration	Howell		7.6	26.1	6.3	9.9	34 00
B 59	Unicorn Dairy Ration	Saginaw		6.6	28.6	7.3	10.7	1 80
B 26	Unicorn Dairy Ration	Mt. Pleasant		7.3	26.1	5.1	10.0	32 00
		Average		7.2	27.4	6.2	10.3	....
			*G.	......	16.5	3.0	12.0	....
B 146	Lactola Dairy Feed	Lansing	*F.	7.8	17.4	3.0	10.4	$1 30
B 170	Lactola Dairy Feed	Howell		13.1	18.2	1.0	8.7	28 00
B 655	Lactola Dairy Feed	North Adams		10.7	16.3	2.6	8.6	1 35
B 735	Lactola Dairy Feed	Ontonagon		10.6	14.8	3.1	11.2	1 65
B 1296	Lactola Dairy Feed	Battle Creek		8.4	19.0	3.0	9.7	27 00
		Average		10.1	17.1	2.5	9.7	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Albert Dickinson Co., Chicago, Ill.							
			*G.	......	10.0	3.5	10.0	....
B 730	White Cross Stock Feed	Iron River	*F.	11.1	11.5	3.0	4.8	$1 65
B 1264	White Cross Stock Feed	Paw Paw		10.9	9.5	4.1	4.5	1 60
		Average		11.0	10.5	3.6	4.7	....
	Golden Grain Milling Co., East St. Louis, Ill.							
			*G.	......	14.0	2.5	15.0	....
B 201	Golden Grain Dairy Feed	Detroit	*F.	8.3	18.6	3.3	17.7	$29 00
	Hales & Edwards, Chicago, Ill.							
			*G.	......	16.0	4.0	12.0	....
B 1232	Red Horn Dairy Feed	So. Haven	*F.	10.5	18.1	3.4	10.6	$1 60
	Kellogg Toasted Corn Flakes Co., Battle Creek, Mich.							
			*G.	......	16.5	4.5	6.5	....
B 1274	Invincible Dairy Feed	Battle Creek	*F.	6.8	20.9	4.2	7.1	$25 00
	Chas. A. Krause Milling Co., Milwaukee, Wis.							
			*G.	......	16.0	3.0	15.0	....
B 33	Badger Dairy Feed	Alma	*F.	8.1	18.4	2.7	12.4	$30 00
B 155	Badger Dairy Feed	Howell		8.7	17.2	5.7	15 0	1 30
B 446	Badger Dairy Feed	Grand Rapids		8.8	17.3	6.4	14.2	26 00
B 521	Badger Dairy Feed	Forest Grove		7.7	15.9	3.5	21.7	29 00
B 569	Badger Dairy Feed	Jamestown		8.5	16.0	3.6	20.0	28 00
		Average		8.4	17.0	4.4	16.7	....
			*G.	......	12.0	1.0	30.0	....
B 447	Badger Evergreen Feed	Grand Rapids	*F.	15.1	10.6	0.9	18.4	$26 00
			*G.	......	10.0	4.5	12.0	....
B 344	Badger Stock Feed	Niles	*F.	9.1	8.9	3.2	14.1	1 60
B 389	Badger Stock Feed	Dowagiac		8.7	10.1	4.9	11.7	1 60
B 585	Badger Stock Feed	Greenville		9.2	9.9	5.4	9.9	30 00
B 1259	Badger Stock Feed	Paw Paw		8.5	8.8	4.6	11.4	1 65
		Average		8.9	9.4	4.5	11.8	....
	Larrowe Milling Co., Detroit, Mich.							
			*G.	......	19.0	3.0	14.0	....
B 128	Larro-Feed	Lansing	*F.	8.6	18.5	3.9	11.6	$1 70
B 153	Larro-Feed	Howell		8.1	19.9	3.4	12.3	1 65
B 215	Larro-Feed	Mason		9.8	21.3	3.4	12.1	1 65
B 253	Larro-Feed	Jackson		9.3	21.1	3.1	11.9	1 65
B 466	Larro-Feed	Grand Rapids		8.3	19.9	3.5	12.2	33 00
B 490	Larro-Feed	Grandville		9.5	21.0	3.8	12.1	34 00
B 531	Larro-Feed	Zeeland		9.3	21.8	4.0	11.4	30 00
		Average		9.0	20.5	3.6	11.9	....
	Lichtenberg & Son, Detroit, Mich.							
			*G.	......	23.0	4.0	12.0	....
B 70	Faramel Dairy Feed	Saginaw	*F.	6.9	24.1	4.9	9.4	$1 75
B 135	Faramel Dairy Feed	Lansing		8.6	24.2	4.4	8.5	34 00
B 188	Faramel Dairy Feed	Detroit		6.6	27.9	7.3	12.1	30 00
B 606	Faramel Dairy Feed	Chelsea		6.8	29.5	6.7	10.8	1 85
B 621	Faramel Dairy Feed	Ypsilanti		9.9	25.2	4.5	9.2	1 60
B 626	Faramel Dairy Feed	Milan		7.9	26.7	5.6	9.4	1 75
		Average		7.8	26.3	5.6	9.9	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	McMorran Milling Co., Port Huron, Mich.							
			*G.	......	22.0	2.0	10.0	....
B 833	Protean Feed	Port Huron	*F.	10.3	26.6	2.3	8.4	$30 00
	Northern Illinois Cereal Co., Lockport, Ill.							
			*G.	......	9.0	3.0	12.0	....
B 322	Peru C & O Feed	Detroit	*F.	10.7	8.4	2.5	8.2	$1 40
	Omaha Alfalfa Milling Co., Omaha, Nebraska.							
			*G.	......	20.0	3.0	18.0	....
B 75	Cream Alfalfa Dairy Feed No. 1	Saginaw	*F.	7 6	20.7	2.1	13.2	$1 50
B 280	Cream Alfalfa Dairy Feed No. 1	Detroit		8.4	20.3	3.0	14.9	....
B 430	Cream Alfalfa Dairy Feed No. 1	Grand Rapids		8.7	18.6	2.9	14.0	30 00
B 514	Cream Alfalfa Dairy Feed No. 1	Vriesland		8.1	20.8	3.0	12.5	33 00
B 571	Cream Alfalfa Dairy Feed No. 1	Zeeland		8.0	21.3	3.4	14.6	34 00
		Average		8.2	20.3	2.9	13.8	....
			*G.	......	16.0	2.5	18.0	....
B 74	Cream Alfalfa Dairy Feed No. 2	Saginaw	*F.	8.0	19.8	2.2	14.2	$1 45
			*G.	......	11.0	1.0	25.0	....
B 428	Green Meadow Dairy Feed	Grand Rapids	*F.	19.1	13.6	1.1	16.3	25 00
B 515	Green Meadow Dairy Feed	Vriesland		15.9	9.0	0.8	15.3	26 00
B 588	Green Meadow Dairy Feed	Reed City		15.1	15.7	0.5	17.4	35 00
B 1030	Green Meadow Dairy Feed	Traverse City		9.5	12.8	0.4	19.8	31 00
		Average		14.9	12.8	0.7	17.2	....
	Purina Mills Branch, Ralston Purina Co., St. Louis, Missouri.							
			*G.	......	18.5	3.5	12.0	....
B 478	Protena Dairy Feed	Grand Rapids	*F.	8.7	18.9	3.9	10.0	$28 00
	Quaker Oats Co., Chicago, Ill.							
			*G.	......	25.0	3.5	12.0	....
B 157	Blue Ribbon Dairy Feed	Howell	*F.	7.8	21.1	5.0	10.2	$34 00
			*G.	......	8.0	1.4	2.0	....
B 1310	Maz-All Feed	Battle Creek	*F.	4.9	8.2	1.2	1.2	23 50
			*G.	......	16.0	4.0	14.5	....
B 542	Quaker Dairy Feed with Molasses	Grand Haven	*F.	8.6	15.2	5.1	15.2	30 00
			*G.	......	10.0	3.3	10.0	....
B 507	Schumacher Stock Feed	Coopersville	*F.	8.2	11.6	5.0	9.9	28 00
B 623	Schumacher Stock Feed	Ypsilanti		8.9	10.9	3.8	10.4	1 60
B 647	Schumacher Stock Feed	Jerome		9.1	11.2	3.8	9.8	1 50
B 665	Schumacher Stock Feed	Adrian		9.8	11.0	3.4	7.3	30 00
B 682	Schumacher Stock Feed	Tecumseh		9.4	12.2	3.8	7.1	1 30
B 724	Schumacher Stock Feed	Iron River		9.2	13.3	3.6	9.3	2 00
B 748	Schumacher Stock Feed	Houghton		9.5	10.1	3.1	10.8	1 60
B 710	Schumacher Stock Feed	Crystal Falls		9.2	10.9	3.4	8.7	1 60
		Average		9.2	11.4	3.7	9.2	....
	Ryde & Company, Chicago, Ill.							
			*G.	......	4.2	0.8	4.5	....
B 1205	Ryde's Supreme Molasses Feed	Kalamazoo	*F.	15.7	4.7	1.1	4.9	$1 75
	The Sugarine Co., Peoria, Ill.							
			*G.	......	10.0	3.5	12.0	....
B 435	Suco Fat Maker	Grand Rapids	*F.	14.1	8.6	1.4	1.2	$25 50
B 1008	Suco Fat Maker	Whitecloud		11.9	13.1	4.4	8.6	32 00
		Average		13.0	10.9	2.9	4.9	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	The Sugarine Co., Peoria, Ill.—Concluded.							
			*G.	......	16.5	3.5	12.0	....
B 436	Sugarine Dairy Feed	Grand Rapids	*F.	10.4	18.4	5.5	14.7	$25 50
B 537	Sugarine Dairy Feed	Spring Lake		9.6	18.5	5.3	14.8	30 00
B 1268	Sugarine Dairy Feed	Paw Paw		8.5	18.4	5.4	14.6	1 50
		Average		9.5	18.4	5.4	14.7	....
	Ubiko Milling Co., Cincinnati, Ohio.							
			*G.	......	24.0	7.0	9.0	....
B 162	Biles Ready Dairy Ration	Howell	*F.	7.6	24.4	7.0	8.9	$33 50
B 811	Biles Ready Dairy Ration	Flint		7.3	24.2	7.2	10.5	34 00
B 927	Biles Ready Dairy Ration	Coldwater		8.0	23.8	6.5	9.8	1 70
		Average		7.6	24.1	6.9	9.7	....
	Watson Bros., Detroit, Mich.							
			*G.	......	9.3	9.6	2.0	....
B 919	Excelsior Stock Feed	Detroit	*F.	9.4	8.5	8.1	2.0	$10 00
	Western Grain Products Co., Hammond, Indiana.							
			*G.	......	10.0	2.5	13.0	....
B 401	Chicago Alfalfa Horse & Mule Feed	Grand Rapids	*F.	11.4	13.8	2.2	12.0	$30 00
			*G.	......	16.5	3.5	11.0	....
B 402	Hammond Dairy Feed	Grand Rapids	*F.	9.7	15.4	3.6	13.8	25 50
B 498	Hammond Dairy Feed	Jenison		7.4	16.7	4.9	12.0	27 00
B 532	Hammond Dairy Feed	Zeeland		10.9	15.5	5.2	11.6	31 00
B 1288	Hammond Dairy Feed	Battle Creek		10.0	15.2	5.0	11.2	26 00
		Average		9.5	15.7	4.7	12.2	....
	HORSE FEEDS.							
	American Milling Co., Peoria, Ill.							
			*G.	......	10.0	2.5	12.0	....
B 638	Sucrene Horse Feed with Alfalfa	Monroe	*F.	12.4	10.6	2.9	9.3	$29 00
B 911	Sucrene Horse Feed with Alfalfa	Mt. Clemens		17.5	9.4	2.7	8.8	1 70
B 1210	Sucrene Horse Feed with Alfalfa	Kalamazoo		10.9	10.2	3.0	9.1	1 55
		Average		13.6	10.1	2.9	9.1	....
			*G.	......	10.0	2.5	12.0	....
B 1013	Tip Top Alfalfa Horse Feed	Fremont	*F.	15.2	9.8	2.8	10.1	$32 00
	Arcady Farms Milling Co., Chicago, Ill.							
			*G.	......	9.0	1.5	12.0	....
B 438	Arcady Horse Feed	Grand Rapids	*F.	9.8	10.8	1.6	14.6	$30 00
B 879	Arcady Horse Feed	Pontiac		13.0	10.9	1.8	12.4	1 75
		Average		11.4	10.9	1.7	13.5	....
	J. J. Badenoch Co., Chicago, Ill.							
			*G.	......	10.0	2 0	12.0	....
B 1258	Glos Koat	Paw Paw	*F.	16.1	11 0	1.6	12.6	$1 65
			*G.	......	10.0	2 0	12.0	....
B 1250	Grain Gold Horse & Cattle Feed	Paw Paw	*F.	10.2	10.6	3.7	10.5	1 65
	Albert Dickinson Co., Chicago, Ill.							
			*G.	......	9.0	1.5	15.0	....
B 173	Hobby Horse Feed	Detroit	*F.	9.6	12.8	1 8	12.9	$29 00
B 534	Hobby Horse Feed	Grand Haven		13.8	11.4	2.7	11.3	32 00
B 547	Hobby Horse Feed	Muskegon Heights		11.7	10.8	2.7	9.8	32 00
B 619	Hobby Horse Feed	Ypsilanti		15.0	11.8	2.3	10.3	1 70
B 886	Hobby Horse Feed	Royal Oak		9.1	11.9	2 1	11.8	1 70
B 1005	Hobby Horse Feed	Holland		8.9	11.8	2.2	10.8	34 00
B 1206	Hobby Horse Feed	Kalamazoo		9.6	11.6	2.2	11.5	1 60
		Average		11.1	11.7	2.3	11 2	....
			*G.	......	10.0	0.5	25.0	....
B 546	Honeysuckle Feed	Muskegon Hts.	*F.	14.4	12.3	1 2	20.0	$27 00
			*G.	......	10.0	2.5	8.0	....
B 354	White Cross Horse Feed	Niles	*F.	11.2	9.5	3.4	3.9	1 80
B 383	White Cross Horse Feed	Dowagiac		11.3	9.1	3.1	3.5	1 90
		Average		11.3	9.3	3.3	3.7	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Golden Grain Milling Co., East St. Louis, Ill.							
			*G.	......	10.0	2.0	12.0	....
B 199	Ben Hur Horse Feed	Detroit	*F.	13.2	10.3	2.1	8.1	$35 00
B 202	Ben Hur Horse Feed	Detroit		11.1	10.9	2.4	9.3	35 10
		Average		12.2	10.6	2.3	8.7	....
			*G.	......	9.0	1.5	14 0	....
B 200	Puritan Horse Feed	Detroit	*F.	9.9	11.6	3.3	14 0	$33 10
B 308	Puritan Horse Feed	Detroit		9.9	9.1	1.7	16.3	1 45
		Average		9.9	10.4	2.5	15.2	....
	Hales & Edwards, Chicago, Ill.							
			*G.	......	10.0	3.0	8.0	....
B 355	Excelsior Horse Feed	Niles	*F.	10.8	11.2	3.3	5.0	$1 80
B 1229	Excelsior Horse Feed	So. Haven		11.7	9.5	3.2	4.4	1 90
		Average		11.3	10.4	3.3	4.7	....
			*G.	......	10.0	0.5	26.0	....
B 1237	Greeno Feed	So. Haven	*F.	17.2	13.0	0.6	14.1	$1 40
			*G.	......	10.0	2.0	15.0	....
B 62	Harvest Horse Feed	Saginaw	*F.	7.5	12.8	1 7	13.3	1 75
B 360	Harvest Horse Feed	Niles		9 1	10.9	2.3	12.3	1 60
B 1240	Harvest Horse Feed	St. Joseph		15.3	11.4	1.5	14.3	1 40
B 1295	Harvest Horse Feed	Battle Creek		12.3	12.1	1.9	13 0	32 50
		Average		11.1	11.8	1.9	13.2	....
			*G.	......	10.0	2.5	9.0	....
B 1236	Pioneer Feed	....	*F.	10.4	9.6	2 7	8.6	$1 60
	Howard H. Hanks, Chicago, Ill.							
			*G.	......	9.0	......	12.0	....
B 397	Polo Feed	Lawton	*F.	12.6	7.4	1.6	10.3	1 80
			*G.	......	9.0	2.0	15.0	....
B 266	Kingfalfa Horse Feed	Jackson	*F.	23.2	11.2	1.1	10.4	28 00
B 298	Kingfalfa Horse Feed	Detroit		13.2	11.1	2.0	11.2	1.50
B 371	Kingfalfa Horse Feed	Niles		16.5	13.2	1.4	14.3	1 60
B 398	Kingfalfa Horse Feed	Lawton		18.3	10.1	1.3	9.8	1 45
		Average		17.8	11.4	1.5	11.4	....
	Chas. A. Krause Milling Co., Milwaukee, Wis.							
			*G.	......	10.0	2 0	12 0	....
B 299	Badger Horse Feed	Detroit	*F.	8.4	11.1	1.5	14.7	$1 60
B 443	Badger Horse Feed	Grand Rapids		9.5	10.9	1 4	14.4	32 00
B 580	Badger Horse Feed	Greenville		9.1	11.2	1.6	9 8	32 00
B 1261	Badger Horse Feed	Paw Paw		9.6	11.1	1.9	15.3	1 65
B 1299	Badger Horse Feed	Battle Creek		16.3	9.8	1.5	13.5	1 75
		Average		10.6	10.8	1.6	13.5	....
			*G.	......	10.0	1.5	14.0	....
B 916	Cream City Horse Feed	Mt. Clemens	*F.	8.1	11.9	0.8	12.0	$1 75
			*G.	......	10.0	1.0	16 0	....
B 1228	Derby Horse Feed	So. Haven	*F.	13.7	9.7	1.3	12.5	1 65
	Lichtenberg & Son, Detroit, Mich.							
			*G.	......	10.0	3.0	8.0	....
B 183	Faramel Horse Feed	Detroit	*F.	12.4	9.1	4.0	7.2	35 00

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Omaha Alfalfa Milling Co., Omaha, Nebraska.							
			*G.	......	10.0	2.0	12.0	....
B 246	Al-Corn-O Horse Feed	Jackson	*F.	10.4	10.0	1.6	12.3	$1 55
B 429	Al-Corn-O Horse Feed	Grand Rapids		22.6	12.0	1.7	11.9	29 00
B 564	Al-Corn-O Horse Feed	Muskegon		16.6	12.2	2.3	11.0	29 00
		Average		16.5	11.4	1.9	11.7	....
			*G.	......	10.0	2.0	12.0	....
B 488	Omaha Special Horse & Mule Feed	Grand Rapids	*F.	16.4	10.9	1.7	11.5	$34 00
			*G.	......	10.0	2.0	12.0	....
B 76	Peerless Alfalmo Horse Feed	Saginaw	*F.	8.6	11.0	2.1	11.2	1 50
B 245	Peerless Alfalmo Horse Feed	Jackson		10 0	9.8	2.9	10 2	1 65
B 481	Peerless Alfalmo Horse Feed	Grand Rapids		9 6	11.6	1.6	12.3	34 00
B 536	Peerless Alfalmo Horse Feed	Spring Lake		10.4	9.8	2.5	9.6	35 00
B 563	Peerless Alfalmo Horse Feed	Muskegon		15.2	9.2	2.3	11.7	30 00
B 614	Peerless Alfalmo Horse Feed	Ann Arbor		10.7	10.2	2.1	11.9	1 65
B 1207	Peerless Alfalmo Horse Feed	Kalamazoo		8.4	10.7	1.7	13 6	1 60
		Average		10.4	10.3	2.2	11.7	....
			*G.	......	10.0	2.0	12.0	....
B 205	Perfection Horse Feed	Detroit	*F.	10.0	10.6	2.5	11.3	$31 00
	M. C. Peters Milling Co., Omaha, Nebraska.							
			*G.	......	9.0	2.0	15.0	....
B 203	Peter's Arab Horse Feed	Detroit	*F.	9.5	11.3	2.3	9.0	35 00
			*G.	......	9.0	1.5	18.0	....
B 473	Peter's King Corn	Grand Rapids	*F.	8.5	11.8	1.8	13.3	35 00
	Quaker Oats Co., Chicago, Ill.							
			*G.	......	9.7	3.7	10.5	....
B 272	Banner Feed	Jackson	*F.	6.8	12.8	1.3	33.7	27 50
B 456	Banner Feed	Grand Rapids		7.6	14.7	1.1	31.9	30 00
		Average		7.2	13.8	1.2	32.8	....
			*G.	......	8.0	3.0	12.0	....
B 648	Boss Feed	Jerome	*F.	9.2	8.3	3.3	9.8	$1 40
			*G.	......	10.0	2.5	12.0	....
B 453	Green Cross Mixed Horse Feed with Molasses	Grand Rapids	*F.	8.8	10.6	2.4	7.5	32 00
B 541	Green Cross Mixed Horse Feed with Molasses	Grand Haven		10.3	10.5	2.4	11.8	34 00
B 620	Green Cross Mixed Horse Feed with Molasses	Ypsilanti		10.7	10.8	2.1	9.6	1 60
		Average		9.9	10.6	2.3	9.6	....
			*G.	......	9.0	2.0	15.0	....
B 457	Golden Sweet Mule Feed	Grand Rapids	*F.	9.3	11.1	2.1	13.8	$26 00
			*G.	......	10.0	2.8	11.0	....
B 662	Horse Power Feed	Adrian	*F.	8.5	12.2	3.1	8.6	32 00
			*G.	......	9.2	3.2	8.0	....
B 646	Schumacher Special Horse Feed	Jerome	*F.	10.8	9.8	3.1	7.9	1 50
			*G.	......	8.0	3.0	12.0	....
B 608	Victor Feed	Ann Arbor	*F.	9.7	9.6	3.8	9.9	1 50
			*G.	......	8.0	3.2	9.0	....
B 231	White Diamond Feed	Jackson	*F.	9.6	8.5	3.6	8.0	1 70
B 362	White Diamond Feed	Niles		9.5	9.3	3.8	6.9	1 75
B 704	White Diamond Feed	Escanaba		10.3	8.9	2 9	7.3	29 00
B 747	White Diamond Feed	Houghton		11.3	8.4	3.0	6.5	1 60
		Average		10.2	8.8	3.3	7.2	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Saginaw Milling Co., Saginaw, Mich.							
			*G.	......	......	......	......	....
B 42	Ground Oats	Saginaw	*F.	9.5	10.9	4.1	9.4	$33 00
	Star of the West Milling Co., Frankenmuth, Mich.							
			*G.	......	8.5	3.6	8.9	....
B 846	Special Feed	Frankenmuth	*F.	11.5	9.4	3.7	5.9	1 70
	Wash. Co. Alfalfa Milling Co., Fort Calhoun, Nebr.							
			*G.	......	9.0	2.0	25.0	....
B 561	Strong Horse Feed	Muskegon	*F.	9.6	11.6	2.1	13.2	30 00
	Western Grain Products Co., Hammond, Indiana.							
			*G.	......	12.0	2.8	12.0	....
B 405	Hammond Horse Feed	Grand Rapids	*F.	9.8	14.1	4.4	11.4	26 00
	POULTRY FEEDS.							
	Allen Milling Co., Niagara Falls, N. Y.							
			*G.	......	......	......	......	....
B 773	Allens Full Nest Growing Chick Food	Chelsea	*F.	12.4	11.1	3.7	2.5	2 10
			*G.	......	......	......	......	....
B 774	Allens Full Nutro Chick Mash	Chelsea	*F.	10.4	16.7	3.6	7.9	2 20
			*G.	......	......	......	......	....
B 775	Allens Full Nest Egg Mash for Layers	Chelsea	*F.	10.0	15.6	1.5	6.8	....
			*G.	......	......	......	......	....
B 772	Allens Full Nest Quality Scratch Food	Chelsea	*F.	12.8	9.6	2.2	2.4	1 95
	Amendt Milling Co., Monroe, Mich.							
			*G.	......	10.0	2.5	5.0	....
B 635	Amco Chick Feed	Monroe	*F.	12.1	9.8	2.5	2.0	1 80
B 904	Amco Chick Feed	Plymouth		11.6	9.6	2.8	2.0	....
		Average		11.9	9.7	2.7	2.0	....
			*G.	......	9.5	2.4	4.3	....
B 321	Amco Scratch Feed	Detroit	*F.	12.5	9.8	2.3	2.3	$1 85
B 634	Amco Scratch Feed	Monroe		12.3	9.6	2.2	2.2	1 60
B 645	Amco Scratch Feed	Trenton		11.4	9.8	2.4	2.4	1 85
		Average		12.1	9.7	2.3	2.3	....
			*G.	......	15.5	2.5	10.0	....
B 636	Amco Poultry Mash	Monroe	*F.	10.4	19.4	4.8	7.4	....
B 644	Amco Poultry Mash	Trenton		8.6	20.9	5.0	8.2	$2 25
		Average		9.5	20.2	4.9	7.8	....
	American Milling Co., Peoria, Ill.							
			*G.	......	10.0	2.5	5.0	....
B 129	Cluck Cluck Scratch Feed	Lansing	*F.	12.0	9.8	3.3	2.5	$2 00
B 206	Cluck Cluck Scratch Feed	Detroit		11.6	9.7	2.8	2.5	33 00
B 277	Cluck Cluck Scratch Feed	Jackson		11.6	8.9	2.3	2.8	32 00
B 805	Cluck Cluck Scratch Feed	Bancroft		12.0	9.5	2.5	2.5	2 00
		Average		11.8	9.5	2.8	2.6	....
			*G.	......	18.0	4.5	9.0	....
B 909	Sucrene Poultry Mash	Utica	*F.	8.7	22.4	5.6	6.8	$1 80
			*G.	......	10.0	2.5	5.0	....
B 639	Sucrene Chick Feed	Monroe	*F.	13.0	10.4	3.3	2.2	33 50
B 778	Sucrene Chick Feed	Royal Oak		12.7	10.3	3.2	2.4	2 25
B 870	Sucrene Chick Feed	Farmington		10.2	10.2	3.2	2.5	2 25
B 1015	Sucrene Chick Feed	Fremont		12.3	10.6	4.2	2.1	40 00
		Average		12.1	10.4	3.5	2.3	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protien.	Crude fat.	Crude fiber.	Price per ton or cwt.
	American Milling Co., Peoria, Ill.—Concluded.							
			*G.	......	10.0	2.5	5.0	....
B 881	Sucrene Scratch Feed	Birmingham	*F.	12.3	10.3	2.7	2.7	$1 95
B 1211	Sucrene Scratch Feed	Kalamazoo		10.2	9.6	2.2	2.2	1 80
		Average		11.3	10.0	2.5	2.5	....
			*G.	......	10.0	2.5	5.0	....
B 150	Tip Top Scratch Feed	Howell	*F.	11.5	10.8	2.7	2.5	$1 90
B 1014	Tip Top Scratch Feed	Fremont		11.7	10.1	2.7	2.8	38 00
B 1212	Tip Top Scratch Feed	Kalamazoo		10.5	9.9	4.3	2.4	1 65
		Average		11.2	10.3	3.2	2.6	....
	Bad Axe Grain Co., Bad Axe, Mich.							
			*G.	......	10.2	2.7	4.8	....
B 867	Egg Brand Poultry Feed	Bad Axe	*F.	11.0	9.6	2.1	2.9	$1 70
	J. J. Badenoch Co., Chicago, Ill.							
			*G.	......	9.5	2.5	5.0	....
B 578	C-er-lay Chick Feed	Belding	*F.	10.4	8.9	2.4	1.7	40 00
B 1020	C-er-lay Chick Feed	Holland		9.8	9.1	2.7	2.0	38 00
		Average		10.1	9.0	2.6	1.9	....
			*G.	......	9.5	2.5	5.0	....
B 111	C-er-lay Poultry Feed	Lansing	*F.	10.2	9.7	2.9	2.5	$2 00
B 207	C-er-lay Poultry Feed	Detroit		10.0	10.1	3.3	2.6	33 00
B 249	C-er-lay Poultry Feed	Jackson		10.2	9.5	2.3	2.4	1 75
B 600	C-er-lay Poultry Feed	Adrian		12.9	9.8	3.0	2.6	1 75
B 1019	C-er-lay Poultry Feed	Holland		10.4	9.8	3.1	3.3	36 00
B 1247	C-er-lay Poultry Feed	Paw Paw		9.8	10.6	3.1	2.5	2 00
B 1284	C-er-lay Poultry Feed	Battle Creek		12.1	10.0	2.9	2.9	2 00
B 1246	C-er-lay Poultry Feed	Paw Paw		8.4	13.5	4.2	6.5	2 00
		Average		10.5	10.4	3.1	3.2	....
			*G.	......	9.5	2.5	5.0	....
B 112	Daily Egg Poultry Feed	Lansing	*F.	11.4	10.3	2.6	2.6	$1 90
			*G.	......	15.0	4.0	8.0	....
B 485	Eg-a-day Meat Cereal Mash	Grand Rapids	*F.	9.9	15.3	4.1	6.3	44 00
			*G.	......	10.0	2.5	5.0	....
B 661	Sunflower Developing Feed	Adrian	*F.	10.7	9.2	2.1	2.1	2 00
			*G.	......	10.0	2.5	5 0	....
B 484	Sunflower Poultry Feed	Grand Rapids	*F.	11.3	10.9	3.0	3.3	40 00
B 924	Sunflower Poultry Feed	Hillsdale		13.1	10.1	3.2	3.0	2 10
B 1283	Sunflower Poultry Feed	Battle Creek		11.4	10.0	2.7	2.5	2 10
B 1313	Sunflower Poultry Feed	Marshall		13.1	9.8	1.1	3.1	2 00
		Average		12.2	10.2	2.5	3.0	....
	J. C. Barrett, South Bend, Ind.							
			*G.	......	12.0	2.0	4.0	....
B 373	Henola Dry Mash	Niles	*F.	7.7	13.1	3.2	4.7	$2 00
	Blatchfords Calf Meal Factory, Waukegan, Ill.							
			*G.	......	19.0	4.0	10.0	....
B 113	Fill-the-Basket Egg Mash	Lansing	*F.	7.9	19.1	4.8	9.5	3 50
B 692	Fill-the-basket Egg Mash	Cheboygan		9.3	18.9	3.6	9.8	3 00
B 878	Fill-the-basket Egg Mash	Pontiac		8.0	19.1	4.9	8.6	2 75
B 902	Fill-the-basket Egg Mash	Plymouth		9.2	18.9	5.1	8.4	2 60
B 929	Fill-the-basket Egg Mash	Coldwater		9.8	19.1	3.9	8.1	2 00
		Average		8.8	19.0	4.5	8.9	....
			*G.	......	20.0	4.0	7.5	....
B 583	Blatchford's Milk Mash	Greenville	*F.	8.7	21.3	3.8	4.5	$80 00
B 693	Blatchford's Milk Mash	Cheboygan		9.4	21.9	4.7	6.6	3 50
B 877	Blatchford's Milk Mash	Pontiac		8.2	19.8	4.3	6.9	3 15
B 903	Blatchford's Milk Mash	Plymouth		8.5	20.0	4.3	6.3	3 50
		Average		8.7	20.1	4.3	6.1	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory Number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	W. Boardman, Benton Harbor, Mich.							
			*G.	......	10.0	2.7	4.0	....
B 1243	Success Scratch Feed	Benton Harbor	*F.	14.0	9.8	1.5	3.0	$1 90
	H. P. Boehm, Benton Harbor, Mich.							
			*G.	......	10.8	3.3	3.7	....
B 1241	Champion Mills Star Chick Feed	Benton Harbor	*F.	16.6	8.9	.....	3.4	2 00
	W. J. Byrnes & Co., Chicago, Ill.							
			*G.	......	10.0	3.0	5.0	....
B 549	Daisy Chick Feed	Muskegon	*F.	11.2	11.8	2.8	2.8	40 00
			*G.	......	9.5	2.5	5.0	....
B 550	Jewel Poultry Feed	Muskegon	*F.	10.4	10.1	2.5	2.6	34 00
			*G.	......	10.0	3.0	5.0	....
B 551	Royal Poultry Feed	Muskegon	*F.	11.3	10.2	2.8	2.4	35 00
	Callam Milling Co., Saginaw, Mich.							
			*G.	......	9.0	3.0	4.0	....
B 845	Bob White Poultry Feed	....	*F.	13.2	9.6	1.5	3.5	1 95
	Caughey Jossman & Co., Detroit, Mich.							
			*G.	......	11.5	2.4	3.1	....
B 287	CCC Baby Chick Feed	Detroit	*F.	10.8	10.9	2.4	2.8	1 80
B 891	CCC Baby Chick Feed	Rochester		10.8	10.7	2.2	3.0	....
		Average		10.8	10.8	2.3	2.9	....
			*G.	......	9.7	3.0	3.3	....
B 286	CCC Scratch Feed	Detroit	*F.	11.2	11.4	3.0	3.1	$1 80
B 890	CCC Scratch Feed	Rochester		12.3	11.2	3.0	3.8	2 00
B 905	CCC Scratch Feed	Oxford		12.3	10.2	2.3	3.1	2 00
		Average		11.9	10.9	2.8	3.3	....
	Cereal Mills Co., Wausau, Wis.							
			*G.	......	9.0	2.0	2.5	....
B 714	Cemco Hen Feed	Crystal Falls	*F.	11.3	9.1	2.6	2.6	$2 25
	Cheboygan Flour Mill Co., Cheboygan, Mich.							
			*G.	......	9.0	3.0	5.0	....
B 690	Highland Scratch Feed	Cheboygan	*F.	12.1	9.9	3.0	4.9	2 00
	Commercial Milling Co., Detroit, Mich.							
			*G.	......	9.0	2.4	4.0	....
B 192	Henkel's Poultry Feed	Detroit	*F.	11.6	9.7	3.4	7.0	34 00
	The C. E. De Puy Co., Pontiac, Mich.							
			*G.	......	8.8	......	2.8	....
B 872	Peerless Scratch Feed	Pontiac	*F.	10.6	10.0	3.1	2.7	1 65
			*G.	......	8.0	2.0	......	....
B 871	Victor Chick Feed	Pontiac	*F.	11.6	10.1	2.1	2.0	1 80
	The Albert Dickinson Co., Chicago, Ill.							
			*G.	......	10.0	2.0	5.0	....
B 352	Colonial Developing Feed	Niles	*F.	11.1	10.3	3.1	2.7	2 25
			*G.	......	10.0	2.5	5.0	....
B 738	Crescent Chick Feed	Ontonagon	*F.	10.0	9.7	2.2	2.2	3 00
B 742	Crescent Chick Feed	Houghton		12.0	9.4	2.1	2.0	2 00
B 925	Crescent Chick Feed	Hillsdale		11.9	11.0	3.2	2.4	2 25
		Average		11.3	10.0	2.5	2.2	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	The Albert Dickinson Co., Chicago, Ill.—Concluded.							
			*G.	......	10.0	2.5	5.0	....
B 325	Globe Chick Feed	Detroit	*F.	12.8	10.4	3.2	1.8	$2.00
B 650	Globe Chick Feed	North Adams		11.6	10.1	2.5	1.9	2.00
B 661	Globe Chick Feed	Adrian		10.2	9.5	2.6	1.7	1.85
B 887	Globe Chick Feed	Royal Oak		11.2	10.7	2.5	2.0	2.40
B 1208	Globe Chick Feed	Kalamazoo		10.4	10.3	2.5	2.7	1 90
B 1300	Globe Chick Feed	Battle Creek		9.9	9.4	1.9	1.8	2 50
		Average		11.0	10.1	2.5	2.0	....
			*G.	......	10.0	2.5	5.0	....
B 651	Globe Developing Feed	North Adams	*F.	12.4	9.8	3.0	2.3	$1.90
B 1003	Globe Developing Feed	Holland		11.0	10.1	3.0	2.7	38.00
		Average		11.7	10.0	3.0	2.5	....
			*G.	......	16.0	3.0	10.0	....
B 71	Globe Egg Mash	Saginaw	*F.	9.4	15.2	4.2	6.4	$2 00
B 107	Globe Egg Mash	Benton Harbor		9.9	16.1	4.3	6.3	2 00
B 290	Globe Egg Mash	Detroit		8.9	15.1	3.7	6.8	2.10
B 767	Globe Egg Mash	Marquette		11.4	14.6	3.9	5.5	2.00
		Average		9.9	15.3	4.0	6.3	....
			*G.	......	10.0	2.5	5.0	....
B 138	Globe Scratch Feed	Lansing	*F.	11.0	10.6	3.5	3.0	$2.10
B 179	Globe Scratch Feed	Detroit		10.6	11.1	3.3	3.1	37.00
B 288	Globe Scratch Feed	Detroit		12.4	10.9	2.7	2.7	1.85
B 426	Globe Scratch Feed	Grand Rapids		12.5	10.6	2.9	2.7	36.00
		Average		11.6	10.8	3.1	2.9	....
			*G.	......	10.0	2.5	5.0	....
B 819	Pine Tree Chick Feed	Lapeer	*F.	12.9	10.4	2.4	2.4	$2.10
			*G.	......	10.0	2.5	5.0	....
B 139	Pine Tree Scratch Feed	Lansing	*F.	11.1	10.6	3.2	2.8	2.05
B 382	Pine Tree Scratch Feed	Dowagiac		11.7	9.6	2.6	2.3	1.90
B 425	Pine Tree Scratch Feed	Grand Rapids		12.6	10.6	3.0	2.3	35 00
B 565	Pine Tree Scratch Feed	Muskegon		12.1	10.0	3.0	2.6	34.00
B 1209	Pine Tree Scratch Feed	Kalamazoo		11.1	10.4	2.7	1.3	1.75
		Average		11.7	10.2	2.9	2.3	....
			*G.	......	9.5	2.5	5.0	....
B 400	Rival Scratch Feed	Kalamazoo	*F.	10.9	10.2	2.7	3.1	$1.65
B 427	Rival Scratch Feed	Grand Rapids		12.5	10.5	3.2	2.8	34.00
		Average		11.7	10.4	3.0	3.0	....
			*G.	......	10.0	2.5	5.0	....
B 175	White Cross Chick Feed	Detroit	*F.	11.1	10.7	3.4	2.3	$39.00
			*G.	......	10.0	2.5	5.0	....
B 16	White Cross Scratch Feed	Owosso	*F.	11.5	10.9	3.3	2.6	1.90
B 172	White Cross Scratch Feed	Detroit		11.5	9.9	3.1	2.6	36.00
B 218	White Cross Scratch Feed	Mason		12.6	10.7	2.9	2.4	2 00
B 240	White Cross Scratch Feed	Jackson		13.1	10.2	2.6	2.4	2.00
B 307	White Cross Scratch Feed	Detroit		10.1	10.4	3.3	2.1	1.90
B 420	White Cross Scratch Feed	Grand Rapids		11.9	10.1	3.1	2.7	38.00
B 1265	White Cross Scratch Feed	Paw Paw		11.4	10.0	2.8	2.7	1.90
		Average		11.7	10.3	3.0	2.5	....
	Grand Rapids Grain & Milling Co., Grand Rapids, Mich.							
			*G.	......	9.3	3.6	4.6	....
B 471	Purity Scratch Feed	Mill Creek	*F.	12.0	9.4	2.7	3.3	$38.00
B 1021	Purity Scratch Feed	Grand Rapids		11.5	9.5	2.8	3.9	....
		Average		11.8	9.5	2.8	3.6	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory Number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Hales & Edwards, Chicago, Ill.							
			*G.	......	10.0	2.5	5.0	....
B 148	Cackle Brand Fine Chick Feed	Lansing	*F.	10.4	9.3	3.3	2.0	$2.00
B 1234	Cackle Brand Fine Chick Feed	So. Haven		10.7	9.0	1.9	1.9	2.00
B 1294	Cackle Brand Fine Chick Feed	Battle Creek		10.4	9.4	2.5	2.3	2.50
		Average		10.5	9.2	2.6	2.1	....
			*G.	......	10.0	2.5	5.0	....
B 225	Cackle Brand Poultry Feed	Jackson	*F.	12.5	9.9	2.9	2.3	$1.90
B 408	Cackle Brand Poultry Feed	Grand Rapids		11.4	10.4	3.1	2.7	35.00
B 1218	Cackle Brand Poultry Feed	Kalamazoo		9.7	10.7	2.7	2.6	1.85
		Average		11.2	10.3	2.9	2.5	....
			*G.	......	10.0	2.5	5.0	....
B 140	Morning Glory Scratch Feed	Lansing	*F.	10.8	10.3	3.3	2.4	$2.05
B 224	Morning Glory Scratch Feed	Jackson		11.5	10.6	2.9	2.3	1.85
		Average		11.2	10.5	3.1	2.4	....
			*G.	......	10.0	2.5	5.0	....
B 824	Red Comb Coarse Chick Feed	Port Huron	*F.	10.9	10.6	2.0	2.1	$2.10
B 1235	Red Comb Coarse Chick Feed	So Haven		12.5	10.4	2.4	2.4	2.10
B 1239	Red Comb Coarse Chick Feed	St. Joseph		11.7	10.4	2.6	2.1	1.95
		Average		11.7	10.5	2.3	2.2	....
			*G.	......	15.0	4.0	8.0	....
B 63	Red Comb Meat Mash	Saginaw	*F.	8.1	16.0	3.8	8.0	$1.90
B 406	Red Comb Meat Mash	Grand Rapids		10.2	15.4	3.3	8.2	39.00
B 825	Red Comb Meat Mash	Port Huron		10.1	15.3	2.8	8.7	2.00
		Average		9.5	15.6	3.3	8.3	....
			*G.	......	10.0	2.5	5.0	....
B 64	Red Comb Poultry Feed	Saginaw	*F.	10.8	10.3	2.8	2.6	$1.90
B 137	Red Comb Poultry Feed	Lansing		11.3	10.3	2.7	2.2	2.05
B 164	Red Comb Poultry Feed	Howell		11.5	10.9	2.4	2.5	2.30
B 407	Red Comb Poultry Feed	Grand Rapids		12.3	11.1	2.9	3.0	37.00
		Average		11.5	10.7	2.7	2.6	....
	Howard H. Hanks Co., Chicago, Ill.							
			*G.	......	9.5	2.5	5.0	....
B 300	Ku-Koo Scratch Feed	Detroit	*F.	10.0	9.6	2.5	2.2	$1.65
B 366	Ku-Koo Scratch Feed	Niles		11.7	10.1	2.7	2.6	1.90
B 369	Ku-Koo Scratch Feed	Niles		9.9	8.9	2.1	2.7	1.90
		Average		10.5	9.5	2.4	2.5	....
			*G.	......	10.0	......	5.0	....
B 364	Golden Egg Coarse Chick Feed	Niles	*F.	10.7	10.1	2.7	2.0	$2.50
			*G.	......	10.0	2.5	5.0	....
B 365	Golden Egg Fine Chick Feed	Niles	*F.	9.5	10.7	3.0	2.1	2.50
			*G.	......	10.0	2.5	5.0	....
B 177	Golden Egg Scratch Feed	Detroit	*F.	10.7	10.6	2.9	2.9	37.00
B 309	Golden Egg Scratch Feed	Detroit		11.0	11.2	3.2	3.0	1.85
		Average		10.9	10.9	3.1	3.0	....
	Henderson Milling Co., Grand Rapids, Mich.							
			*G.	......	10.0	2.5	5.0	....
B 433	Hens Best Scratch Feed	Grand Rapids	*F.	11.7	8.4	2.0	3.0	$34.00
	William Bacon Holmes Co., Chelsea, Mich.							
			*G.	......	9.0	2.5	5.0	....
B 604	Phoenix Chick Feed	Chelsea	*F.	11.1	9.7	2.3	4.2	1.70
			*G.	......	10.0	2.5	5.0	....
B 605	Phoenix Scratch Feed	Chelsea	*F.	13.0	10.4	2.1	3.6	1.80

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	B. B. Hyde, Port Huron, Mich.							
			*G.	......	10.0	3.8	2.2	....
B 826	Ideal Poultry Food	Port Huron	*F.	12.8	9.3	2.4	3.8	$1 80
	The Illinois Feed Mills Branch, Ralston Purina Co., St. Louis, Mo.							
			*G.	......	10.0	3.0	6.0	....
B 377	Feedwell Scratch Feed	Niles	*F.	11.5	9.6	3.5	3.3	....
B 326	Feedwell Scratch Feed	Detroit		12.7	10.7	3.1	2.7	1.85
B 479	Feedwell Scratch Feed	Grand Rapids		10.7	11.5	3.2	2.6	35.00
		Average		11.6	10.6	3.2	2.9	....
			*G.	......	10.0	3.0	6.0	....
B 1219	Star Chick Feed	Kalamazoo	*F.	9.3	9.2	2.2	1.8	$2 00
			*G.	......	10.0	3.0	6.0	....
B 1217	Star Scratch Feed	Kalamazoo	*F.	10.3	12.2	2.5	1.9	1.85
	Chas. A. Krause Milling Co., Milwaukee, Wis.							
			*G.	......	10.0	2.5	5.0	....
B 584	Blue Top Fine Chick Feed, no grit	Greenville	*F.	10.4	9.0	2.9	1.9	40.00
B 777	Blue Top Fine Chick Feed, no grit	Royal Oak		12.6	9.2	2.7	1.9	2.25
B 914	Blue Top Fine Chick Feed, no grit	Mt. Clemens		11.4	9.5	2.7	1.9	2.50
		Average		11.5	9.7	2.8	1.9	....
B 915	Blue Top Fine Chick Feed, with grit	Mt. Clemens	*G.	......	10.0	2.5	5.0	....
			*F.	11.2	9.2	2.6	1.8	$2.75
			*G.	......	10.0	2.5	5.0	....
B 577	Blue Top Scratch Feed, no grit	Belding	*F.	12.5	9.9	3.3	2.5	40 00
B 923	Blue Top Scratch Feed, no grit	Hillsdale		12.6	10.0	3.4	2.9	2.10
		Average		12.6	10.0	3.4	2.7	....
			*G.	......	10.0	2.5	5.0	....
B 581	Blue Top Scratch Feed, with grit	Greenville	*F.	11.8	9.4	2.9	2.8	$45.00
	Marinette Flour Mills Co., Marinette, Wis.							
			*G.	......	9.0	2.0	5.0	....
B 708	Plymouth Rock Every Day Poultry Feed	Iron Mountain	*F.	9.8	8.5	2.2	2.6	2.25
B 763	Plymouth Rock Every Day Poultry Feed	Negaunee		9.9	8.4	1.9	2.7	2.25
		Average		9.9	8.5	2.1	2.7	....
	McMorran Milling Co., Port Huron, Mich.							
			*G.	......	8.0	2.0	5.0	....
B 834	Crest Brand Poultry Feed	Port Huron	*F.	11.6	11.1	2.6	4.5	$1.07
	The Model Milling Co., Port Huron, Mich.							
			*G.	......	10.2	3.3	3.5	....
B 900	Model Scratch Feed	St. Clair	*F.	12.1	10.0	2.4	3.3	2.25
	Northrup King & Co., Minneapolis, Minn.							
			*G.	......	10.0	2.5	5.0	....
B 745	Sterling Chick Feed	Houghton	*F.	11.5	11.3	2.1	2.9	2 00
			*G.	......	10.0	2.5	5.0	....
B 740	Sterling Scratch Feed	Houghton	*F.	11.5	9.2	2.5	2.6	1.80
	The New Century Co., Detroit, Mich.							
			*G.	......	9.5	2.5	5.0	....
B 197	Cadillac Scratch Feed	Detroit	*F.	9.5	9.8	2.5	3.0	36.00
			*G.	......	10.0	2.5	5.0	....
B 198	New Century Scratch Feed	Detroit	*F.	10.6	10.2	2.8	2.4	37.00

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Osceola Mill & Elevator Co., Osceola, Wis.							
			*G.	......	10.0	3.0	5.0	....
B 769	Gopher Brand Hen Feed	Newberry	*F.	12.9	10.2	2.8	3.1	$2 25
	Postum Cereal Co., Battle Creek, Mich.							
			*G	......	8.0	1.0	15.0	....
B 1280	Chicken Feed	Battle Creek	*F.	8.9	11.6	2.4	3.9	26 00
	Prairie State Milling Co., Chicago, Ill.							
			*G.	......	10.0	2.5	5.0	....
B 557	Garland Scratch Feed	Muskegon	*F.	12.8	10 0	2.9	2.7	36 00
			*G.	......	10.0	2.5	5.0	....
B 558	Prairie State Scratch Feed	Muskegon	*F.	11.5	10.1	3.4	2.9	37 00
			*G.	......	10.0	2.5	5.0	....
B 114	Red Crown Scratch Feed	Lansing	*F.	10.2	10.4	2.8	3.3	1.85
B 212	Red Crown Scratch Feed	Mason		12.5	10.7	3.6	3.2	2.00
B 942	Red Crown Scratch Feed	Homer		11 8	12.4	2.5	3.4	2.10
		Average		11.5	11.2	3.0	3.3	....
	Purina Mills Branch Ralston Purina Co., St. Louis, Mo.							
			*G.	......	17.0	3.0	9.0	....
B 376	Purina Chicken Chowder Feed	Niles	*F.	9.1	18.6	3.9	7.8	$2.25
B 469	Purina Chicken Chowder Feed	Grand Rapids		8.2	20.0	4.2	8.2	46 00
B 920	Purina Chicken Chowder Feed	Jonesville		9.8	19.1	3.9	7.8	2 25
B 1301	Purina Chicken Chowder Feed	Battle Creek		9.4	19.1	4.2	7.4	2 50
		Average		9.1	19.2	4.3	7.8	....
			*G.	......	11.0	3.0	4.0	....
B 476	Purina Chicken Feed	Grand Rapids	*F.	11.9	10.1	2.7	2.5	$45 00
			*G.	......	11.0	3.0	4.0	....
B 323	Purina Scratch Feed	Detroit	*F.	12.7	10.9	3.3	2.4	2 15
B 477	Purina Scratch Feed	Grand Rapids		11.7	10.6	3.1	3.4	40.00
		Average		12.2	10.8	3.2	2.9	....
	Quaker Oats Co., Chicago, Ill.							
			*G.	......	10.0	2.5	5.0	....
B 749	American Hen Scratch Grains	Houghton	*F.	11.0	10.0	2.8	2.8	$1.85
			*G.	......	10.0	2.5	5.0	....
B 746	Big Egg Scratch Grains	Houghton	*F.	12.0	10.6	3.1	3.3	1.75
			*G.	......	10.0	2.5	5.0	....
B 607	Pansy Scratch Grains with grit	Ann Arbor	*F.	12.4	8.9	2.3	2.6	1.85
B 734	Pansy Scratch Grains with grit	Ironwood		10.9	9.6	2.7	2.0	1 85
B 741	Pansy Scratch Grains with grit	Houghton		11.4	9.1	2.4	2 1	1 80
B 1214	Pansy Scratch Grains with grit	Kalamazoo		11.1	9.2	3.0	1.9	2 00
		Average		11.5	9.2	2.6	2.2	....
			*G.	......	10.0	2.5	5.0	....
B 505	Quaker Chick Feed	Coopersville	*F.	11.1	10.8	3.2	2.6	$50 00
B 751	Quaker Chick Feed	Houghton		11.3	9.6	2.6	2.5	1 95
		Average		11.2	10.2	2.9	2.6	....
			*G.	......	10.0	2.5	5.0	....
B 709	Quaker Scratch Grains	Crystal Falls	*F.	11.5	10.8	2.7	2.9	$2 25
			*G.	......	10.0	2.5	5.0	....
B 610	Schumacher Little Chick Feed	Ann Arbor	*F.	12.6	10.0	2.2	2.6	1 85
B 1215	Schumacher Little Chick Feed	Kalamazoo		10.6	10.3	2.7	2.4	1 90
		Average		11.6	10.2	2.5	2.5	....
			*G.	......	10.0	2.5	5.0	....
B 705	Schumacher Scratch Grains	Menominee	*F.	12.9	9.8	2.8	2.5	$1 65
B 725	Schumacher Scratch Grains	Iron River		11.6	9.8	2.3	2.3	3 25
		Average		12.3	9.8	2.6	2.4	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Roach & Seeber, Houghton, Mich.							
B 761	Roseco Scratch Feed	Marquette	*G.	......	10.0	2.5	5.0	....
			*F.	13.1	10.6	2.8	3.1	$35 00
	Saginaw Milling Co., Saginaw, Mich.							
B 43	Red Hen Dry Mash	Saginaw	*G.	......	16.5	3.5	10.0	....
			*F.	8.6	18.9	4.5	9.0	36 00
B 1041	Red Hen Scratch Feed	Cadillac	*G	......	11.0	2.5	5 0	....
			*F	12.4	9 4	2.8	2.5	45 00
	Scheuren & Mok, Detroit, Mich.							
B 318	Bran Mash	Detroit	*G.	......	......	......	......	....
			*F.	10.1	16.6	3.5	8.6	1 25
B 311	Eagle Scratch Feed	Detroit	*G.	......	10.0	3.8	4.4	....
			*F.	10.3	10.0	2 8	2.4	1 75
B 312	Pride Chick Feed	Detroit	*G.	......	11.0	3.6	3.0	....
			*F.	11.2	11.9	3.7	3.5	2 00
	Scofield & Son, Jackson, Mich.							
B 234	Scofield's Dry Mash	Jackson	*G.	......	17.4	......	8.0	....
			*F.	9.1	19.9	3.8	10.8	2 25
	Standard Grocer & Milling Co., Holland, Mich.							
B 599	Standard Scratch Feed	Holland	*G.	......	10.0	2.7	3.1	....
			*F.	11.8	9.6	2.3	2.5	37 00
	F. J. Stuart, Pontiac, Mich.							
B 876	Stuart's Chicken Feed	Pontiac	*G.	......	8.6	2.8	3.3	....
			*F.	12.0	8.9	3.4	3.0	2 00
	The Sugarine Co., Peoria, Ill.							
B 306	Ideal Scratch Feed	Detroit	*G.	......	10.0	2.5	5.0	....
			*F.	11.7	10.9	3.0	2.7	1 85
B 305	Sugarine Scratch Feed	Detroit	*G.	......	10.0	2.5	5.0	....
			*F.	11.4	11.1	2.4	2.2	2 00
	Thunder Bay Milling Co. Alpena, Mich.							
B 688	Thunder Bay Scratch Feed	Alpena	*G.	......	10.8	3.0	3.8	....
			*F.	11.9	11.1	2.9	3.7	1 85
	The Toledo Grain & Milling Co., Toledo, Ohio.							
B 678	Camp's Red Ball Chick Feed	Morenci	*G.	......	10.0	2.5	5.0	....
			*F.	11.1	10.1	2.2	2.1	2 50
B 677	Camp's Red Ball Scratch Feed	Morenci	*G.	......	10.0	2.5	5.0	....
			*F.	11.3	9.9	2.8	2.6	2 10
	Watson Higgins Milling Co., Grand Rapids, Mich.							
B 418	Perfection Scratch Feed	Grand Rapids	*G.	......	10.4	2.4	3.4	....
			*F.	14.5	9.9	2.2	3.4	34 00
B 502	Perfection Scratch Feed	Coopersville		11.2	10.1	2.4	2.3	36 00
B 540	Perfection Scratch Feed	Grand Rapids		12.6	9.3	......	2.9	38 00
		Average		12.8	9.8	2 3	2.9	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—Continued.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Willy & Co., Appleton, Wis.							
B 721	Hen Feed	Iron River	*G.	......	10.0	2.4	4.8	....
			*F.	10.0	9.6	2.0	3.1	$2 25
	C. C. Wright, Owosso, Mich.							
B 8	Wright's Mixture	Owosso	*G.	......	9.0	3.0	5.0	....
			*F.	12.8	10.5	2.6	3.3	2 00
	CORN & OAT FEEDS.							
	Alma Grain & Lumber Co., Alma, Mich.							
B 35	Ground Feed	Alma	*G.	......	......	......	......	....
			*F.	11.4	10.3	3.3	3.6	1 60
	Amendt Milling Co., Monroe, Mich.							
B 633	Amco Chop Feed	Monroe	*G.	......	7.9	3.9	10.9	....
			*F.	11.5	9.5	3.6	6.9	1 50
B 642	Amco Chop Feed	Trenton		10.7	10.3	3.8	6.4	1 50
		Average		11.1	9.9	3.7	6.7	....
	J. J. Badenoch Co., Chicago, Ill.							
B 1252	C & O Chop	Paw Paw	*G.	......	9 0	3.0	12.0	....
			*F.	9.1	8 4	.4	12.0	$1 60
	Beck Cereal Co., Detroit, Mich.							
B 204	Royal Chop Feed	Detroit	*G.	......	8.3	5.	5.8	....
			*F.	11.0	8.9	4.1	4.9	28 00
B 291	Royal Chop Feed	Detroit		11.7	8.4	3 9	7.0	1 50
B 302	Royal Chop Feed	Detroit		10.0	8.7	4 4	6.4	1 40
B 882	Royal Chop Feed	Birmingham		13.1	8.7	4 2	5.9	1 65
		Average		11.5	8.7	4 2	6.1	....
	H. P. Boehm, Benton Harbor, Mich.							
B 1242	Corn & Oats	Benton Harbor	*G.	......	......	......	......	....
			*F.	11.1	8.8	3.2	5.9	$1 70
	Brand & Harden, Saginaw, Mich.							
B 72	No. 1 Ground Feed	Saginaw	*G.	......	......	......	......	....
			*F.	11.6	9.1	3.8	4.3	1 65
	C. Breisch & Co., Lansing, Mich.							
B 98	No. 1 Ground Feed	Lansing	*G.	......	......	......	......	....
			*F.	13.2	8.8	......	3.5	33 00
	Briggs & Co., Paw Paw, Mich.							
B 1270	Chop (Corn, Rye, Oats)	Paw Paw	*G.	......	......	......	......	....
			*F.	10.5	9.6	2.9	3.6	1 75
	Brown & Thompson, Coloma, Mich.							
B 1245	Corn & Oats	Coloma	*G.	......	......	......	......	....
			*F.	12.0	9 7	3.5	1.8	1 50

***Abbreviations for Guaranteed and Found.**

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Callam Mills, Saginaw, Mich.							
B 60...	No. One Fine Feed	Saginaw	*G.	......	......	......	......	....
			*F.	11.5	10.6	3.4	3.5	$1 65
	Cereal Mills Co., Wausau, Wis.							
B 713	Corn & Oats Ground Feed	Crystal Falls	*G.	......	10.0	7.0	7.0	....
			*F.	10.1	11.6	5.5	4.6	2 00
	Colby Milling Co., Dowagiac, Mich.							
B 395	Street Car Feed	Dowagiac	*G.	......	......	......	......	....
			*F.	12.2	10.4	3.5	3.0	34 00
B 394	Corn & Oats	Dowagiac	*G.	......	......	......	......	....
			*F.	11.5	10.8	2.9	3.1	29 00
	Commercial Milling Co., Detroit, Mich.							
			*G.	......	9.0	4.5	9.0	....
B 193	Henkels Chop Feed	Detroit	*F.	10.0	9.4	4.4	7.1	29 00
B 598	Henkels Chop Feed	Howard City		11.0	9.6	4.1	6.6	35 00
B 686	Henkels Chop Feed	Alpena		10.4	9.5	4.7	6.3	1 70
B 893	Henkels Chop Feed	Rochester		13.4	8.8	2.8	8.0	1 70
B 897	Henkels Chop Feed	Armada		11.1	8.8	3.6	6.0	1 80
		Average		11.2	9.2	4.2	6.8	....
	Dowagiac Coal & Ice Co., Dowagiac, Mich.							
B 391	Corn & Oats	Dowagiac	*G.	......	......	......	......	....
			*F.	16.0	8.8	1.9	4.3	$1 70
	Grand Rapids Grain & Milling Co., Grand Rapids, Mich.							
B 439	Ground Corn & Oats	Grand Rapids	*G.	......	......	......	......	....
			*F.	10.8	8.3	2.1	1.9	32 00
B 441	Street Car Feed	Grand Rapids	*G.	......	......	......	......	....
			*F.	13.6	9.3	3.3	5.4	32 00
	Howard H. Hanks, Chicago, Ill.							
B 292	Hammer Feed	Detroit	*G.	......	......	......	......	....
			*F.	10.8	10.0	3.4	4.5	1 80
	Henderson Milling Co., Grand Rapids, Mich.							
B 415	Street Car Feed	Grand Rapids	*G.	......	......	......	......	....
			*F.	12.1	8.9	3.8	3.3	35 00
			*G.	......	......	......	......	....
B 1230	Chop Feed	So. Haven	*F.	15.8	7.3	......	1.9	1 75
B 1266	Chop Feed	Paw Paw		13.5	7.8	......	1.9	1 75
		Average		14.7	7.6	......	1.9	....
	A. L. Hibbard Feed Mill, Sturgis, Mich.							
B 935	A 1 Chop Feed	Sturgis	*G.	......	8.8	4.3	4.8	....
			*F.	12.3	9.2	3.3	10.5	$1.45
	H. M. Hobart & Son, Detroit, Mich.							
B 918	P & H Chop Feed	Detroit	*G.	......	8.8	3.9	5.2	....
			*F.	13.2	7.6	2.1	4.1	1 30

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	D. D. Holden, Jackson, Mich.							
			*G.	......	......	......	......	....
B 235	No. 1 Corn & Oats	Jackson	*F.	14.9	9.5	......	2.8	$1 80
	Johnston & Howard, Kalamazoo, Mich.							
			*G.	......	......	......	......	....
B 1204	Chop Feed	Kalamazoo	*F.	12.6	8.2	2.9	......	1 70
	King Milling Co., Lowell, Mich.							
			*G.	......	10.4	6.5	6.2	....
B 575	Corn & Oat Feed	Lowell	*F.	11.2	9.5	4.7	3.7	32 00
	Lichtenburg & Son, Detroit, Mich.							
			*G.	......	7.7	......	9.4	....
B 185	Chop Feed	Detroit	*F.	10.1	11.0	3.9	5.5	28 00
	Mason Milling Co., Mason, Mich.							
			*G.	......	......	......	......	....
B 209	No. 1 Chop Feed	Mason	*F.	10.3	10.1	2.7	5.5	....
B 223	No. 1 Chop Feed	Mason		15.5	10.6	......	4.8	1 60
		Average		12.9	10.4	2.7	5.2	....
	McLaughlin & Ward, Jackson, Mich.							
			*G.	......	......	......	......	....
B 254	No. 1 Corn & Oats	Jackson	*F.	9.3	9.6	2.4	5.4	$1 75
	McMorran Milling Co., Port Huron, Mich.							
			*G.	......	7.0	2.0	17.0	....
B 835	Crest Brand Chop	Port Huron	*F.	12.5	9.7	5.6	6.5	30 00
	Northern Illinois Cereal Co., Lockport, Ill.							
			*G.	......	9.0	3.0	12.0	....
B 261	Peru Corn & Oats Feed	Jackson	*F.	9.5	8.1	2.1	8.0	27 00
	Northern Milling Co., Wausau, Wis.							
			*G.	......	9.0	3.0	8.0	....
B 715	Northern Feed	Crystal Falls	*F.	10.8	10.1	3.3	3.8	2 00
	F. E. Nowlin Co., Albion, Mich.							
			*G.	......	......	......	......	....
B 1316	Corn & Oats	Albion	*F.	11.7	9.8	3.0	5.9	1 75
	Owosso Milling Co., Owosso, Mich.							
			*G.	......	......	......	......	....
B 17	Corn & Oats	Owosso	*F.	11.1	11.6	3.5	5.8	1 75
	C. A. Parshall & Co., Howell, Mich.							
			*G.	......	......	......	......	....
B 167	Ground Corn & Oats	Howell	*F.	10.2	10.4	3.7	7.0	1 70
	F. G. Rapp, South Haven, Mich.							
			*G.	......	......	......	......	....
B 1222	Chop Feed	So. Haven	*F.	15.7	10.2	2.0	3.6	1 75
	Reliance Mercantile Co., Saginaw, Mich.							
			*G.	......	......	......	......	....
B 66	Ground Feed No. 1	Saginaw	*F.	9.7	9.6	3.6	5.3	1 75
	Saginaw Milling Co., Saginaw, Mich.							
			*G.	......	......	......	......	....
B 37	No. 1 Feed	Saginaw	*F.	8.7	11.0	5.0	4.7	31 00
			*G.	......	......	......	......	....
B 44	Street Car Feed	Saginaw	*F.	13.6	9.3	3.3	5.4	31 00
	Scheuren & Mok, Detroit, Mich.							
			*G.	......	7.0	2.7	5.3	....
B 314	Chop Feed	Detroit	*F.	13.4	6.8	2.0	5.7	1 40
	Stockbridge Elevator Co., Jackson, Mich.							
			*G.	......	10.0	2.5	5.0	....
B 255	No. 1 Corn & Oats	Jackson	*F.	13.9	8.8	3.2	5.4	1 90

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—Continued.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	David Stott Milling Co., Detroit, Mich.							
			*G.	......	8.0	5.0	10 0	....
B 669	Winner Chop Feed	Adrian	*F.	10.4	9.1	5.1	5.9	$26 00
B 697	Winner Chop Feed	Cheboygan		11.1	8.6	4.5	6.5	1 40
		Average		10.8	8.9	4.8	6 2	....
	T. B. Taylor, Jackson, Mich.							
			*G.	......	......	......	......	....
B 230	No. 1 Ground Feed	Jackson	*F.	18.7	8.5	......	3.4	$1 75
	Thoman Milling Co., Lansing, Mich.							
			*G.	......	......	......	......	....
B 117	No. 1 Ground Feed	Lansing	*F.	11.3	11.1	4.8	3.2	1 70
	G. W. Thorpe, Jackson, Mich.							
			*G.	......	......	......	......	....
B 244	Corn & Oats	Jackson	*F.	23.0	9.1	......	4.6	1 75
	Titus & Hicks, Battle Creek, Mich.							
			*G.	......	......	......	......	....
B 1293	Corn & Oats	Battle Creek	*F.	11.1	10.0	4.7	5.2	1 75
	Watson Higgins Co., Grand Rapids, Mich.							
			*G.	......	......	......	......	....
B 458	Street Car Feed	Grand Rapids	*F.	13.9	9.7	......	5.3	32 00
	Fred Welsh, Owosso, Mich.							
			*G.	......	......	......	......	....
B 14	Corn & Oats Ground Feed	Owosso	*F.	10.9	11.2	3 2	3.8	1 50
	Wenonah Mills, Bay City, Mich.							
			*G.	......	......	......	......	....
B 91	No. 1 Ground Feed	Bay City	*F.	9.8	10.4	3.5	4.5	1 65
	Wykes & Co., Grand Rapids, Mich.							
			*G.	......	......	......	......	....
B 401	Y X Street Car Feed	Grand Rapids	*F.	12.6	9.4	3.0	2.9	32 00
			*G.	......	......	......	......	....
B 403	Y X Fine Feed	Grand Rapids	*F.	13.4	9.3	3.1	3.0	32 00
	Young Bros. & Daley, Lansing, Mich.							
			*G.	......	......	......	......	....
B 134	No. 1 Mixed Feed	Lansing	*F.	11.6	10.9	3.4	6.2	1 80
	Zantenga & Workman, Kalamazoo, Mich.							
			*G.	......	......	......	......	....
B 1220	Street Car Feed	Kalamazoo	*F.	13.2	9.1	2.5	3.6	1 65
	WHEAT BRAN.							
	Abilene Milling Co., Arkansas City, Kan.							
B 1009	Wheat Bran with ground screenings	White Cloud	*G.	......	......	......	......	....
			*F.	10.0	17.4	3.8	9.8	26 00
	Atlas Flour Mills, Milwaukee, Wis.							
B 1221	Atlas Wheat Bran with Ground Screenings not to Exceed Mill Run		*G.	......	13.0	3.0	11.0	....
		So. Haven	*F.	9.6	13.8	4.6	10.3	1 30
	C. Breisch & Co., Lansing, Mich.							
			*G.	......	......		......	....
B 96	Choice Michigan Wheat Bran	Lansing	*F.	9.6	13.6	3.9	8.8	....
B 144	Choice Michigan Wheat Bran	Lansing		9.3	13.0	4.0	8.7	1 30
B 214	Choice Mich'gan Wheat Bran	Mason		9.8	14.8	4 0	9 4	1 40
B 217	Choice Michigan Wheat Bran	Mason		9.6	14.1	3.6	8.7	1 35
		Average		9.6	13.9	3.9	8.9	....
	J. P. Burroughs & Son, Flint, Michigan.							
			*G.	......	......	......	......	....
B 849	Choice Winter Bran with Ground Screenings not Exceeding Mill Run	Birch Run	*F.	10.7	12.8	3.5	8.6	$1 35

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—Continued.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	L. Christian & Co., Minneapolis, Minn.							
B 556	Wheat Bran with Ground Screenings not Exceeding Mill Run	Muskegon	*G.	......	15.0	4.0	10.0	....
			*F.	9.3	13.9	4.6	11.0	$23 50
B 596	Matchless Wheat Bran	Howard City	*G.	......	15.0	4.0	10.0	....
			*F.	9.7	13.1	4.4	10.6	29 00
	Colby Milling Co., Dowagiac, Mich.							
B 392	Bran no screenings	Dowagiac	*G.	......	......	......	......	....
			*F.	10.3	15.1	4.1	8.5	24 00
	Commercial Milling Co., Detroit, Mich.							
B 151	Henkels Bran	Howell	*G.	......	14.5	3.5	12.0	....
			*F.	8.7	15.5	4.0	10.2	1 60
B 194	Henkels Bran	Detroit		8.7	14.1	4.7	9.7	25 00
B 282	Henkels Bran	Detroit		8.9	14.1	4.2	9.2	1.15
B 296	Henkels Bran	Detroit		10.3	14.7	4.9	9.3	1 30
		Average		9.2	14.6	4.5	9.6	....
	Crookston Milling Co., Crookston, Minn.							
B 757	Coarse Bran Ground Screenings not Exceeding Mill Run	Hancock	*G.	......	14.1	5.0	12.0	....
			*F.	11.5	14.5	5.4	10.0	24 50
	John P. Dausman Milling Co., De Pere, Wis.							
B 728	Coarse Bran	Iron River	*G.	......	14.0	4.5	9.0	....
			*F.	9.8	15.1	5.3	10.5	1 40
	Duluth Superior Milling Co., Duluth, Minn.							
B 752	Duluth Imperial Bran	Houghton	*G.	......	14.5	3.8	12.3	....
			*F.	11.7	14.4	5.1	9.9	25 00
	Duluth Universal Milling Co., Duluth, Minn.							
B 171	Wheat Bran	Detroit	*G.	......	14.6	4.0	12.3	....
			*F.	8.9	13.1	4.4	10.4	24 00
B 766	Wheat Bran with Ground Screenings not Exceed- Mill Run	Marquette	*G.	......	14.6	4.0	12.3	....
			*F.	10.5	13.0	4.2	9.8	1 20
	Eagle Roller Mill Co., New Ulm, Minn.							
B 726	Wheat Bran with Ground Screenings not Exceeding Mill Run	Iron River	*G.	......	14.0	3.4	11.0	....
			*F.	10.8	18.8	4.2	8.6	1 40
B 727	Wheat Bran with Ground Screenings not Exceeding Mill Run	Iron River		10.3	15.1	4.6	9.9	1 40
B 770	Wheat Bran with Ground Screenings not Exceeding Mill Run	Sault Ste. Marie		9.6	14.8	4.5	11.1	1 40
		Average		10.2	16.2	4.4	9.9	....
	B. A. Eckhart Milling Co., Chicago, Ill.							
B 102	Bran with ground screenings not exceeding mill run	Benton Harbor	*G.	......	14.0	4.0	11.0	....
			*F.	9.4	15.4	4.3	9.5	$1 30
B 388	Bran with ground screenings not exceeding mill run	Dowagiac		10.0	15.8	4.2	9.2	1 25
B 416	Bran with ground screenings not exceeding mill run	Grand Rapids		11.2	15.3	4.0	8.9	28 00
B 555	Bran with ground screenings not exceeding mill run	Muskegon		9.6	15.3	4.5	11.2	25 50
B 625	Bran with ground screenings not exceeding mill run	Ypsilanti		10.5	15.5	3.9	9.6	1 30
		Average		10.1	15.5	4.2	9.7	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Eldred Milling Co., Jackson, Mich.							
			*G.	......	16.2	5.0	9.2	....
B 232	Pure Bran	Jackson	*F.	9.3	14.4	4.3	8.4	$1 35
B 236	Pure Bran	Jackson		9.5	14.3	4.2	9.0	1 35
B 603	Pure Bran	Rives Junction		10.3	14.8	4.2	8.3	1 40
		Average		9.7	14.5	4.3	8.6	....
	Empire Milling Co., Minneapolis, Minn.							
B 1035	Wheat Bran with Ground Screenings not exceeding mill run		*G.	......	14.0	4.0	11.0	....
		Charlevoix	*F.	10.0	14.4	5.2	9.3	22 00
	Everett Augenbaugh & Co., Waseca, Minn.							
B 560	Wheat Bran with Ground Screenings not exceeding mill run		*G.	......	14.0	3.0	12.0	....
		Muskegon	*F.	9.1	14.3	5.2	10.7	$23 50
	Goshen Milling Co., Goshen, Ind.							
			*G.	......	14.0	4.0	10.0	....
B 379	Bran no Screenings	Niles	*F.	9.7	15.0	4.2	3.6	1 25
	The Grain Products Co.							
B 431	Wheat Bran with Ground Screenings not exceeding mill run		*G.	......	14.5	3.0	10.0	....
		Grand Rapids	*F.	9.9	17.1	3.9	8.6	25 00
	J. Hale & Son, Ionia, Mich.							
			*G.	......	14.0	3.5	7.5	....
B 23	Flake Bran	Mt. Pleasant	*F.	8.4	14.1	3.3	7.0	1 50
	Hankey Milling Co., Petoskey, Mich.							
			*G.	......	13.6	3.8	9.6	....
B 1039	Bran with Mill Run of Screenings	Petoskey	*F.	9.7	14.5	4.5	9.3	24 00
	Harris Milling Co., Mt. Pleasant, Mich.							
			*G.	......	......	......	......	....
B 28	Bran	Mt. Pleasant	*F.	8.3	14.3	3.4	10.1	25 00
B 30	Bran	Mt. Pleasant		8.2	15.4	4.5	9.4	23 00
		Average		8.3	14.9	4.0	9.8	....
	Hunter-Robinson Wenz Milling Co.							
B 530	Wheat Bran with Ground Screenings not exceeding mill run		*G.	......	15.5	4.0	11.0	....
		Zeeland	*F.	9.7	15.6	4.3	10.0	$26 00
	W. J. Jenison Co., Jenison, Mich.							
B 509	Wheat Bran with Ground Screenings not exceeding mill run		*G.	......	15.0	4.0	10.0	....
		Nunica	*F.	9.4	14.4	4.5	8.7	26 00
B 716	Wheat Bran with Ground Screenings not exceeding mill run	Crystal Falls		9.9	14.5	4.5	10.6	1 40
B 761	Wheat Bran with Ground Screenings not exceeding mill run	Negaunee		10.2	13.9	4.5	10.9	1 40
		Average		9.8	14.3	4.5	10.1	....
	Jonesville Milling Co., Jonesville, Mich.							
			*G.	......	......	......	......	....
B 258	Pure Winter Wheat Bran	Jackson	*F.	9.9	12.8	3.9	9.3	$1 30

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—Continued.

Laboratory Number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Kemper Milling Co., Kansas City, Mo.							
B 1263	Anchor Bran with Ground Screenings not exceeding mill run	Paw Paw	*G.	......	14.5	4.0	10.0	....
			*F.	9.2	17.8	4.4	8.8	$1 40
B 830	Anchor Bran with Ground Screenings not exceeding mill run	Port Huron		10.0	15.1	3.7	10.3	28 00
		Average		9.6	16.5	4.1	9.6	....
	J. B. A. Kern & Sons, Milwaukee, Wis.							
B 543	Eagle Wheat Bran with Ground Screenings not exceeding mill run	Grand Haven	*G.	......	14 5	3.0	10.0	....
			*F.	10.3	15.6	4.3	10.4	$27 00
B 1001	Eagle Wheat Bran with Ground Screenings not exceeding mill run	Holland		9.5	15.8	3.1	10.4	26 00
		Average		9.9	15.7	3.7	10.4	....
	Kimball Milling Co.							
B 262	Globe Mills Pure Wheat Bran	Jackson	*G.	......	15.0	3.0	10.0	....
			*F.	10.0	17.9	3.6	9.4	$24 00
	Larrabee Flour Mills.							
B 264	Wheat Bran with mill run of Screenings not to exceed 8 per cent	Jackson	*G.	......	15.0	3.5	10.5	....
			*F.	9.8	16.1	3.3	8.9	34 00
	John C. Liken & Co., Sebewaing, Mich.							
B 862	Winter Wheat Bran	Pigeon	*G.	......	12.0	3.0	12.0	....
			*F.	7.6	13.4	3.8	9.8	1 50
	Lindsborg Milling Co., Lindsborg, Kansas.							
B 1304	Wheat Bran and 8 per cent Screenings	Battle Creek	*G.	......	14.5	3.5	10.0	....
			*F.	9 7	17.6	4.0	8.5	1 35
	Marshall Milling Co., Marshall, Minn.							
B 493	Wheat Bran with Ground Screenings not exceeding mill run	Grandville	*G.	......	15.0	4.8	11.8	....
			*F.	10.6	13.8	4.5	10.8	28 00
B 759	Wheat Bran with Ground Screenings not exceeding mill run	Negaunee		10.7	13.9	4.9	10.3	1 30
		Average		10.7	13.9	4.7	10.6	....
	Mason Milling Co., Mason, Mich.							
			*G.	......	......	......	......	....
B 210	Bran	Mason	*F.	8.5	15.1	4.4	9.2	$1 50
B 213	Bran	Mason		9.6	13.3	4.0	11.6	1 40
		Average		9.1	14.2	4.2	10.4	....
	National Feed Co., St. Louis, Mo.							
B 182	Wheat Bran with Screenings not exceeding mill run	Detroit	*G.	......	14.5	4.0	10.0	....
			*F.	8.8	16.5	3.4	8.4	$24 00
B 860	Wheat Bran with Screenings not exceeding mill run	Vassar		10.7	17.2	3.8	8.6	28 00
B 1285	Wheat Bran with Screenings not exceeding mill run	Battle Creek		9.2	16.3	3.5	8.0	1 35
		Average		9.6	16.7	3.6	8.3	....
	New Era Milling Co., Arkansas City, Kan.							
B 378	Wheat Bran & Screenings	Niles	*G.	......	16.0	3.5	10.1	....
			*F.	9.0	17.5	3.7	4.0	$1 25

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—Continued.

Laboratory number.	Manufacturer and Trade name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Northern Milling Co., Wausau, Wis.							
			*G.	......	13.0	3.3	12.0	....
B 723	Bran..	Iron River......	*F.	9.7	13.9	5.2	11.0	$1 40
	C. A. Parshall & Co., Howell, Mich.							
			*G.	......	......	......	......	....
B 165	Bran..	Howell.........	*F.	10.4	14.4	4.0	9.3	1 30
	Pillsbury Flour Mills Co., Minneapolis, Minn.							
			*G.	......	14.5	4.0	12.0	....
B 695	Pillsbury's Wheat Bran........................	Cheboygan.....	*F.	10.0	13.4	5.1	11.0	1 25
B 700	Pillsbury's Wheat Bran........................	Escanaba............		10.0	13.6	4.8	11.7	24 00
		Average..........		10.0	13.5	5.0	11.7	....
	G. P. Plant Milling Co., St. Louis, Mo.							
			*G.	......	15.0	3.0	11.0	....
B 554	Wheat Bran with Ground Screenings not exceeding mill run	Muskegon......	*F.	9.3	15.9	4.5	10.2	$23 50
B 1203	Wheat Bran with Ground Screenings not exceeding mill run...............................	Kalamazoo..........		8.7	16.4	4.0	9.0	1 35
B 1231	Wheat Bran with Ground Screenings not exceeding mill run	So. Haven...........		8.8	16.8	4.7	10.0	1 35
		Average..........		8.9	16.4	4.4	9.7	....
	Saginaw Milling Co., Saginaw, Mich.							
			*G.	......	15.0	4 0	11.0	....
B 38	Blue Bird Feed Bran............................	Saginaw........	*F.	8.5	14.1	4.1	8.8	$24 00
			*G.	......	15.0	4.0	11.0	....
B 41	Samico Feed Hard Wheat Bran with Ground Screenings..................................	Saginaw........	*F.	8.3	14.2	4.6	10.4	24 00
B 856	Samco Feed Hard Wheat Bran with Ground Screenings..................................	Vassar...............		10.0	14.1	5.0	10.1	27 00
		Average..........		9.2	14.2	4.8	10.3	....
			*G.	......	15.0	4.0	11.0	....
B 840	Winter Wheat Bran with Ground Screenings not exceeding mill run..........................	Sandusky.......	*F.	9.8	13.4	4.2	8.7	$1 40
	Schultz Baujan & Co., Beardstown, Ill.							
			*G.	......	15.0	3.3	12.0	....
B 562	Wheat Bran with Grouud Screenings not exceeding mill run..................................	Muskegon......	*F.	9.7	15.6	4.5	9.8	23 50
	Sheffield King Milling Co., Minneapolis, Minn.							
			*G.	......	13.5	3.5	12.7	....
B 361	Fancy Brodflake Wheat Bran and Ground Wheat Screenings...........................	Niles...........	*F.	9.2	13.1	4.5	10.6	1 25
	Smokey Valley Roller Mills, Lindborg, Kansas.							
			*G.	......	14.5	3.5	10.0	....
B 351	Wheat Bran & Screenings not to exceed mill run...	Niles...........	*F.	10.1	16.3	3.8	10.0	1 25
	Southwestern Milling Co., Kansas City, Mo.							
			*G.	......	16.5	4.0	10.0	....
B 482	Wheat Bran with Ground Screenings not exceeding Mill Run...............................	Grand Rapids...	*F.	9.5	16.9	3.9	9.4	27 00
B 831	Wheat Bran with Ground Screenings not exceeding mill run...............................	Port Huron..........		10.2	17.9	3.5	8.5	28 00
B 1026	Wheat Bran with Ground Screenings not exceeding mill run...............................	Traverse City.........		10.3	16.6	4.0	9.5	26 00
B 1287	Wheat Bran with Ground Screenings not exceeding mill run...............................	Battle Creek..........		9.9	16.7	3.8	8.5	25 00
		Average..........		10.0	16.7	3.6	8.3	....
	Sparks Milling Co., Terre Haute, Ind.							
			*G.	......	15.0	3.5	10.0	....
B 423	Try Me Bran with Ground Screenings not exceeding mill run...............................	Grand Rapids...	*F.	10.4	13.4	4.0	10.2	$23 00
	Standard Tilton Milling Co., St. Louis, Mo.							
			*G.	......	14.5	4.0	9.5	....
B 278	Wheat Bran with Ground Screenings not exceeding mill run...............................	Jackson........	*F.	9.5	16.9	4.2	9.1	24 00

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—Continued.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Star & Crescent Milling Co., Chicago, Ill.							
B 227	Star & Crescent Bran with Ground Screenings not exceeding mill run	Jackson	*G.	.....	15.0	4.0	10.0	....
			*F.	9 0	15.3	4.9	10.7	$1 30
B 494	Star & Crescent Bran with Ground Screenings not exceeding mill run	Grandville		11.0	16.2	3.9	8.5	23 00
B 513	Star & Crescent Bran with Ground Screenings not exceeding mill run	Vriesland		10.4	15.6	4.1	9.6	26 00
B 525	Star & Crescent Bran with Ground Screenings not exceeding mill run	Zeeland		11.1	15.5	4.1	9.8	26 00
		Average		10.4	15.7	4.3	9.6	....
	Peter Stepanck, Nebraska.							
B 454	Acme Mills & Elevator Bran & Screenings	Grand Rapids	*G.	......	14.8	3 0	10.0	....
			*F.	10.6	16.0	3.9	8.6	$25 00
	F. W. Stock & Sons, Hillsdale, Mich.							
			*G.	......	14.0	3.0	10.0	....
B 241	Bran	Jackson	*F.	9.3	15.4	4.9	9.0	1 40
B 1202	Bran	Kalamazoo		8.9	15.6	4.4	8.7	1 35
B 1314	Bran	Marshall		9.7	14.2	4.4	9.2	26 00
		Average		9.3	15.1	4.6	9.0	....
	David Stott Milling Co., Detroit, Mich.							
B 327	Bran	Detroit	*G.	......	......	......	......	....
			*F.	10.1	13.9	4.9	10.0	$1 45
	John Strong & Son, Detroit, Mich.							
B 181	Winter Wheat Bran	Detroit	*G.	......	15.0	4.5	......	....
			*F.	8.2	12.7	4.2	8.5	24 00
	Thoman Milling Co., Lansing, Mich.							
B 118	Bran	Lansing	*G.	......	......	......	......	....
			*F.	8.7	15.0	3.9	9.5	1 25
	Universal Milling Co., Duluth, Minn.							
B 294	Wheat Bran	Detroit	*G.	......	......	......	......	....
			*F.	10.9	13.6	4.0	9.6	1 30
	Valley City Milling Co., Grand Rapids, Mich.							
B 424	Farmers Favorite Bran with Ground Screenings not exceeding mill run	Grand Rapids	*G.	......	15 9	3.9	9.7	....
			*F.	10.4	13.4	4.0	10.2	23 00
B 520	Farmers Favorite Bran with Ground Screenings not exceeding mill run	Forest Grove		10.1	14.4	3.9	10.3	27 00
B 538	Farmers Favorite Bran with Ground Screenings not exceeding mill run	Spring Lake		9.3	13.9	4.3	11.7	28 00
B 592	Farmers Favorite Bran with Ground Screenings not exceeding mill run	Reed City		9.3	15.0	4.5	9.0	29 00
		Average		9.8	14.2	4.2	10.3	....
	Voigt Milling Co., Grand Rapids, Mich.							
B 475	Wheat Bran with Screenings not exceeding mill run	Grand Rapids	*G.	......	16.0	4.5	10.0	....
			*F.	9.6	14.7	4.1	7.7	....
B 496	Wheat Bran with Screenings not exceeding mill run	Berlin		9.1	15.7	4.8	9.4	$23 00
B 544	Wheat Bran with Screenings not exceeding mill run	Grand Haven		10.5	14.8	4.5	8.1	27 00
B 545	Wheat Bran with Screenings not exceeding mill run	Muskegon Heights		9.8	14.1	4.4	9.8	28 00
B 1043	Wheat Bran with Screenings not exceeding mill run	Cadillac		10.2	14.7	4.2	8.2	32 00
B 1225	Wheat Bran with Screenings not exceeding mill run	So. Haven		10.4	14.0	4.0	8.6	1 40
		Average		9 9	14.7	4.3	8.6	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—Continued.

Laboratory Number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Walton Milling Co., Lansing, Mich.							
			*G.	......	......	......	......	....
B 94	Bran	Lansing	*F.	9.2	14.1	4.4	5.6	$1 40
B 132	Bran	Lansing		8.9	13.6	4.0	10.1	1 30
		Average		9.1	13.9	4.2	7.9	....
	Washburn Crosby Co., Minneapolis, Minn.							
B 158	Wheat Bran with Ground Screenings not exceeding mill run		*G.	......	14.5	4.0	12.0	....
		Howell	*F.	8.8	14.1	5.1	10.0	$30 00
B 101	Wheat Bran with Ground Screenings not exceeding mill run	Benton Harbor		8.8	13.7	5.6	11.3	1 30
B 350	Wheat Bran with Ground Screenings not exceeding mill run	Niles		9.7	13.9	5.5	11.5	1 25
B 1216	Wheat Bran with Ground Screenings not exceeding mill run	Kalamazoo		9.2	13.4	4.9	10.5	1 45
B 1253	Wheat Bran with Ground Screenings not exceeding mill run	Paw Paw		8.7	13.7	5.7	11.2	1 40
		Average		9.1	13.8	5.3	10.8	....
	Watson Higgins Milling Co., Grand Rapids, Mich.							
B 450	Wheat Bran with Ground Screenings not exceeding mill run		*G.	......	......	......	......	....
		Grand Rapids	*F.	10.0	13.4	3.7	9.0	$26 00
B 597	Wheat Bran with Ground Screenings not exceeding mill run	Howard City		9.7	14.1	4.2	9.3	29 00
		Average		9.9	13.8	4.0	9.2	....
	Western Flour Mill Co., Davenport, Iowa.							
			*G.	......	13.1	4.5	10.5	....
B 1012	Black Hawk Bran	Cadillac	*F.	10.1	14.8	4.5	10.2	$31 00
	WHEAT MIDDLINGS.							
	Atlas Flour Mills, Milwaukee, Wis.							
			*G.	......	13.5	3.5	10.5	....
B 445	Standard Wheat Middlings	Grand Rapids	*F.	10.0	14.9	3.9	11.4	28 00
	Baldwin Flour Mills Co., Minneapolis, Minn.							
B 744	Wheat Flour Middlings, Ground Screenings not exceeding mill run		*G.	......	16.5	5.0	7.0	....
		Houghton	*F.	10.9	16.1	5.6	6.4	1 45
	Bay State Milling Co., Winona, Wis.							
			*G.	......	15.0	5.0	8.0	....
B 712	Winona Wheat Middlings	Crystal Falls	*F.	10.2	16.3	5.9	7.2	....
	Bernet Craft & Kauffman Milling Co., St. Louis, Mo.							
B 589	Wheat Middlings with Ground Screenings not exceeding mill run		*G.	......	16.3	4.9	6.0	....
		Reed City	*F.	10.7	15.8	3.8	4.5	34 00
	Big Diamond Mills Co., Minneapolis, Minn.							
B 817	Wheat Flour Middlings with Ground Screenings not exceeding mill run		*G.	......	14.5	4.5	7.8	....
		Lapeer	*F.	9.3	16.3	4.7	5.9	33 00
B 816	Wheat Standard Middlings with Ground Screenings not exceeding mill run		*G.	......	14.7	4.2	9.5	....
		....	*F.	9.9	15.7	4.4	7.6	29 00
	C. Breisch & Co., Lansing, Mich.							
			*G.	......	......	......	......	....
B 97	Middlings	Lansing	*F.	10.9	15.6	4.3	4.7	25 00
B 219	Middlings	Mason		11.3	16.3	4.4	4.6	1 50
		Average		11.1	16.0	4.4	4.7	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	J. P. Burroughs & Son, Flint, Mich.							
B 86	Fancy Winter Middlings with Ground Screenings not exceeding mill run	Bay City	*G.	......	......	......	......	....
			*F.	8.9	15.6	4.6	3.6	$1 60
B 848	Fancy Winter Middlings with Ground Screenings not exceeding mill run	Birch Run		11.1	14.0	4.2	3.7	1 50
		Average		10.0	14.8	4.4	3.7	....
	Callam Mills, Saginaw, Mich.							
B 61	Middlings	Saginaw	*G.	......	......	......	......	....
			*F.	10.0	13.8	3.7	4.1	$1 55
	L. Christian & Co., Minneapolis, Minn.							
B 820	Matchless Red Dog Ground Middlings	Port Huron	*G.	......	16.4	3.2	1.6	....
			*F.	10.5	15.5	2.7	1.8	1 80
	Colby Milling Co., Dowagiac, Mich.							
			*G.	......	......	......	......	....
B 100	Middlings	Benton Harbor	*F.	11.0	14.1	3.6	2.6	1 80
B 381	Middlings	Dowagiac		11.9	13.6	3.8	3.0	1 60
B 387	Middlings	Dowagiac		12.2	13.8	3.6	2.7	1 55
B 393	Middlings	Dowagiac		11.9	13.3	3.5	2.4	29 00
		Average		11.8	13.7	3.6	2.7	....
	Commander Mill Co., Minneapolis, Minn.							
B 679	Wheat Flour Middlings Ground Screenings not exceeding mill run	Clinton	*G.	......	15.0	4.0	9.0	....
			*F.	9.8	15.8	5.3	6.8	$1 45
	The Commercial Milling Co., Detroit, Mich.							
B 196	Wheat Fine Middlings with Ground Screenings not exceeding mill run	Detroit	*G.	......	15.0	4.0	6.0	....
			*F.	9.3	14.8	5.4	5.4	30 00
B 874	Wheat Fine Middlings with Ground Screenings not exceeding mill run	Pontiac		8.8	15.9	5.8	5.7	1 55
		Average		9.1	15.4	5.6	5.6	....
B 595	Standard Wheat Middlings with Ground Screenings not exceeding mill run	Howard City	*G.	......	13.5	4.5	10.0	....
			*F.	9.5	15.4	6.5	9.0	$30 00
B 195	Standard Wheat Middlings with Ground Screenings not exceeding mill run	Detroit		9.9	13.8	5.5	8.5	25 00
B 283	Standard Wheat Middlings with Ground Screenings not exceeding mill run	Detroit		9.2	14.8	3.7	6.5	1 15
B 672	Standard Wheat Middlings with Ground Screenings not exceeding mill run	Morenci		9.0	15.3	6.3	9.1	1 40
B 818	Standard Wheat Middlings with Ground Screenings not exceeding mill run	Lapeer		9.9	15.2	5.7	8.8	1 60
B 883	Standard Wheat Middlings with Ground Screenings not exceeding mill run	Birmingham		11.3	15.4	5.4	8.2	1 35
B 888	Standard Wheat Middlings with Ground Screenings not exceeding mill run	Royal Oak		10.0	15.9	6.0	8.8	1 40
B 1201	Standard Wheat Middlings with Ground Screenings not exceeding mill run	Kalamazoo		9.5	15.1	6.2	7.9	1 45
		Average		9.8	15.1	5.7	8.4	....
	Crookston Milling Co., Crookston, Minn.							
B 756	Flour Middlings with ground Screenings not exceeding mill run	Hancock	*G.	......	15.6	3.0	2.0	....
			*F.	11.7	14.3	3.8	3.2	$30 00
	John P. Dausman Milling Co., De Pere, Wis.							
B 737	Fine Middlings with Ground Screenings not exceeding mill run	Ontonagon	*G.	......	15.0	4.5	9.0	....
			*F.	9.9	15.3	5.0	5.8	1 50

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—Continued.

Laboratory number.	Manufacturer and Trade name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Duluth-Superior Milling Co., Duluth, Minn.							
B 736	White Middlings Ground Screenings not exceeding mill run	Ontonagon	*G.	......	16 5	5.0	7.0	....
			*F.	10.2	14.9	5.2	6.5	$1 50
B 754	Standard S Middlings with Ground Screenings not exceeding mill run	Hancock	*G.	......	16.5	4.8	7.8	....
			*F.	10.7	15.2	5.4	7.7	22 50
	Duluth Universal Milling Co., Duluth, Minn.							
B 755	Wheat Flour Middlings with ground Screenings not exceeding mill run	Hancock	*G.	......	17.0	5.3	5 1	....
			*F.	10.9	15.2	4.7	4.8	27 00
	Eagle Roller Mill Co., New Ulm, Minn.							
B 771	Wheat Middlings with Ground Screenings not exceeding mill run	Sault Ste. Marie	*G.	......	14.2	4.4	10.0	....
			*F.	11.3	15.3	4.2	9.0	1 55
	B. A. Eckhart Milling Co., Chicago, Ill.							
B 409	Flour Middlings	Grand Rapids	*G.	......	15.0	4.0	7.0	....
			*F.	11.2	15.2	3.5	4.1	29 00
B 865	Middlings with Ground Screenings not exceeding mill run	Cass City	*G.	......	14.0	4.0	7.0	....
			*F.	9.4	16.4	4.0	6.5	1 50
	Eldred Milling Co., Jackson Mich.							
			*G.	......	16.9	6.2	6.7	....
B 233	Pure Middlings	Jackson	*F.	10.3	15.2	4.3	6.0	1 55
B 237	Pure Middlings	Jackson		10.3	15.4	4.3	6.7	1 55
B 602	Pure Middlings	Rives Junction		10.5	15.5	4.2	6.2	1 50
		Average		10.4	15.4	4.3	6.3	....
	The Gardner Mills, Hastings, Minn.							
B 762	Snowball Wheat Middlings with Ground Screenings not exceeding mill run	Negaunee	*G.	......	15.0	4.0	7.2	....
			*F.	11.4	15.9	4.8	5.6	$1 60
B 758	Snowball Wheat Middlings with Ground Screenings not exceeding mill run	Hancock		11.5	15.4	4.8	5.5	....
		Average		11.5	15.7	4.8	5.6	....
	Goshen Milling Co., Goshen, Ind.							
B 363	Middlings with Ground Screenings	Niles	*G.	......	14.5	4.1	......	....
			*F.	10.7	14.6	4.0	4.3	$1 60
	Harris Milling Co., Mt. Pleasant, Mich.							
B 32	Middlings	Mt. Pleasant	*G.	......	......	......	......	....
			*F.	7.6	16.0	4.8	4.0	28 00
	The Huron Milling Co., Harbor Beach, Mich.							
B 839	Jenks White Middlings	Sandusky	*G.	......	13.0	2.5	3 5	....
			*F.	10.8	13.3	2.9	2.3	1 75
B 843	Jenks White Middlings	Harbor Beach	*G.	......	13.0	2.5	3.5	....
			*F.	10.9	14.8	3.0	2.7	1 50
	Ismert-Hwake Milling Co., Kansas City, Mo.							
B 1029	I H Standard Middlings with mill run Screenings	Traverse City	*G.	......	17.0	4.5	7.5	....
			*F.	10.6	16.7	3.8	7.2	28 00
	Jonesville Milling Co., Jonesville, Mich.							
B 259	Winter Wheat Middlings	Jackson	*G.	......	......	......	......	....
			*F.	10.2	13.9	3.3	4.1	1 50
	Kehlor Flour Mills, St. Louis, Mo.							
B 85	Rex Middlings with Ground Screenings not exceeding millrun	Bay City	*G.	......	16.0	4.0	7.0	....
			*F.	8.5	18.1	3.7	7.0	1 35
B 586	Rex Middlings with Ground Screenings not exceedings mill run	Reed City		10.9	17.7	3.9	6.4	35 00
		Average		9.7	17.9	3.8	6.7	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—Continued.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	J. B. A. Kern & Sons, Milwaukee, Wis.							
B 733	Wheat Flour Middlings with Ground Screenings not exceeding mill run	Ironwood	*G.	......	15.0	5.0	7.5	....
			*F.	9.3	17.6	5.5	6.4	$1 50
B 58	Wheat Standard Middlings with Ground Screenings not exceeding mill run	Saginaw	*G.	......	14.0	5.0	9.0	....
			*F.	8.6	17.9	5.5	5.2	1 45
B 553	Wheat Standard Middlings with Ground Screenings not exceeding mill run	Muskegon		9.5	16.8	4.9	8.7	25 00
B 652	Wheat Standard Middlings with Ground Screenings not exceeding mill run	North Adams		9.6	17.0	5.2	7.9	1 50
		Average		9.2	17.2	5.2	8.3	....
	King Milling Co., Lowell, Mich.							
			*G.	......	13.5	3.0	7.0	....
B 442	Kimco Middlings	Grand Rapids	*F.	11.1	14.1	4.0	3.5	$31 00
B 574	Kimco Middlings	Lowell		10.7	14.2	4.1	6.4	28 00
B 1034	Kimco Middlings	Charlevoix		11.3	14.1	4.3	6.6	29 50
		Average		11.0	14.1	4.1	5.5	....
	Chas. A. Krause Milling Co., Milwaukee, Wis.							
B 161	Badger Fancy Middlings with Ground Screenings not exceeding mill run	Howell	*G.	......	12.0	4.5	7.0	....
			*F.	9.5	13.4	5.6	3.2	$1 55
B 522	Badger Fancy Middlings with Ground Screenings not exceeding mill run	Forest Grove		9.2	14.1	5.8	4.5	32 00
B 622	Badger Fancy Middlings with Ground Screenings not exceeding mill run	Ypsilanti		10.3	12.0	4.9	3.7	1 70
B 1224	Badger Fancy Middlings with Ground Screenings not exceeding mill run	So. Haven		10.7	12.4	5.6	3.9	....
		Average		9.9	13.0	5.5	3.8	....
	J. C. Liken & Co., Sebewaing, Mich.							
B 864	Winter Wheat Middlings	Pigeon	*G.	......	16.0	4.5	8.0	....
			*F.	9.5	15.6	4.9	5.7	$1 50
	Listman Milling Co., La Crosse, Wis.							
B 706	Elmco Wheat Middlings and Screenings	Menominee	*G.	......	18.2	5.6	10.0	....
			*F.	9.4	17.2	6.2	8.0	1 50
	Madelia Roller Mills, Madelia, Minn.							
B 1036	Wheat Middlings with Ground Screenings not not exceeding mill run	Charlevoix	*G.	......	14.3	3.0	5.4	....
			*F.	10.7	15.4	4.8	6.1	24 60
	Marshall Milling Co., Marshall, Minn.							
B 760	Wheat Shorts Ground Screenings not exceeding mill run	Negaunee	*G.	......	17.0	5.0	9.4	....
			*F.	11.0	15.4	5.0	8.2	1 30
	Mason Milling Co., Mason, Mich.							
B 211	Middlings	Mason	*G.	......	......	......	......	....
			*F.	13.7	13.5	3.0	3.4	1 60
	Michigan Milling Co., Ann Arbor, Mich.							
			*G.	......	......	......	......	....
B 152	Middlings	Howell	*F	9.1	15.0	4.5	5.8	1 60
	National Feed Co., St. Louis, Mo.							
B 189	Wheat Middlings with Ground Screenings not exceeding mill run	Detroit	*G.	......	16.0	4.0	9.0	....
			*F.	9.3	17.8	4.4	6.8	24 00
B 859	Wheat Middlings with Ground Screenings not exceeding mill run	Vassar		11.4	17.3	3.7	6.9	1 50
		Average		10.4	17.6	4.1	6.9	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	New Era Milling Co., Arkansas City, Kan.							
B 375	Middlings and Shorts	Niles	*G.	......	17.0	5.8	10.0	....
			*F.	9.9	16.5	2.9	3.8	$1 60
	New Richmond Roller Mills Co., New Richmond, Wis.							
B 698	White Flour Middlings with Ground Screenings not exceeding mill run	Gladstone	*G.	......	13.0	3.5	9.0	....
			*F.	9.8	14.4	4.8	6.5	1 50
	Northwestern Consolidated Milling Co., Minneapolis, Minn.							
B 696	Wheat Standard Middlings with Ground Screenings not exceeding mill run	Cheboygan	*G.	......	15.0	5.0	11.0	....
			*F.	9.9	15.2	6.1	8.8	1 30
	Northwestern Elevator & Milling Co., Toledo, Ohio.							
B 676	Wheat Middlings with Ground Screenings not exceeding mill run	Morenci	*G.	......	15.0	4.0	6.5	....
			*F.	9.4	15.4	4.0	5.5	30 00
	Owosso Milling Co., Owosso, Mich.							
B 15	Ceedee Middlings	Owosso	*G.	......	......	......	......	....
			*F.	10.4	14.4	4.0	4.3	1 50
	C. A. Parshall & Co., Howell, Mich.							
B 166	Middlings	Howell	*G.	......	......	......	......	....
			*F.	10.8	14.4	4.1	2.4	1 40
	Pillsbury Flour Mills Co., Minneapolis, Minn.							
B 701	Wheat Standard B Middlings with Ground Screenings not exceeding mill run	Escanaba	*G.	......	14.0	4.0	11.0	....
			*F.	10.2	11.9	5.7	10.1	150
B 711	Wheat Standard B Middlings with Ground Screenings not exceeding mill run	Crystal Falls		9.2	15.4	5.8	7.3	1 40
		Average		9.7	15.2	5.8	8.7	....
	G. P. Plant Milling Co., St. Louis, Mo.							
B 1233	Wheat Middlings with Ground Screenings not exceeding mill run	So. Haven	*G.	......	17.0	4.0	6.5	....
			*F.	10.2	17.9	4.5	5.3	$1 50
	Postum Cereal Co., Battle Creek, Mich.							
B 1286	Fine Middlings	Battle Creek	*G.	......	......	......	......	....
			*F.	10.0	15.5	4.1	7.5	1 50
	A. H. Randall Milling Co., Tekonsha, Mich.							
B 356	Middlings	Niles	*G.	......	14.0	3.5	8.0	....
			*F.	10.3	15.3	4.8	5.5	1 60
B 386	Middlings	Dowagiac		11.5	14.7	4.6	5.2	1 45
		Average		10.9	15.0	4.7	5.4	....
	Reliance Mercantile Co., Saginaw, Mich.							
B 65	Middlings	Saginaw	*G.	......	......	......	......	....
			*F.	10.2	13.5	3.5	2.3	$1 60
	Saginaw Milling Co., Saginaw, Mich.							
B 39	Blue Bird Wheat Middlings with Ground Screenings not exceeding mill run	Saginaw	*G.	......	15.0	4.0	11.0	....
			*F.	9.0	14.8	4.6	6.5	26 00
B 841	Blue Bird Wheat Middlings with Ground Screenings not exceeding mill run	Sandusky		9.7	15.0	4.2	6.5	1 75
		Average		9.4	14.9	4.4	6.5	....
B 40	Samico Feed Middlings with Ground Screenings not exceeding mill run	Saginaw	*G.	......	15.0	4.0	11.0	....
			*F.	9.6	15.3	4.3	5.9	$25 00
B 855	Samico Feed Middlings with Ground Screenings not exceeding mill run	Vassar		11.3	15.0	4.9	6.5	29 00
B 861	Samico Feed Middlings with Ground Screenings not exceeding mill run	Caro		9.1	14.4	4.2	6.9	1 60
		Average		10.0	14.9	4.5	6.4	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Pricer per ton or cwt.
	Schultz Baujan & Co., Beardston, Ill.							
B 1025	Sunbeam Middlings with Ground Screenings not exceeding mill run	Manistee	*G.	......	15.0	3.5	10.0	....
			*F.	10.6	16.7	4.1	6.0	$30 00
	Star & Crescent Milling Co., Chicago, Ill.							
B 552	Star & Crescent Middlings with Ground Screenings not exceeding mill run	Muskegon	*G.	......	15.0	4.0	8.0	....
			*F.	9.2	14.1	5.8	4.5	25 00
	F. W. Stock & Sons, Hillsdale, Mich.							
B 242	Wheat Middlings	Jackson	*G.	......	16.5	4.0	6.0	....
			*F.	11.2	15.1	3.7	5.6	1 60
	David Stott Milling Co., Detroit, Mich.							
B 329	Fine White Middlings	Detroit	*G.	......	14.5	4.0	6.0	....
			*F.	9.4	15.4	4.8	4.2	1 50
B 295	Pennant Middlings	Detroit	*G.	......	17.0	5.5	......	....
			*F.	11.1	15.4	4.6	5.3	1 30
	J. Strong & Son, Detroit, Mich.							
B 186	Winter Wheat Peerless Middlings with Ground Screenings not exceeding mill run	Detroit	*G.	......	17.0	5.0	......	....
			*F.	9.4	13.8	4 2	4.5	27 00
	Thoman Milling Co., Lansing, Mich.							
B 119	Middlings	Lansing	*G.	......	......	......	......	....
			*F.	6.6	14.8	4.8	5.8	1 50
	A. H. Tucker, (Concord Mills).							
B 263	Middlings	Jackson	*G.	......	......	......	......	....
			*F.	11.7	13.2	3.5	5.2	27 00
	Universal Milling Co., Duluth, Minn.							
B 293	Wheat Middlings	Detroit	*G.	......	11.0	5.3	5.1	....
			*F.	10.8	16.4	5.3	5.0	1 45
	Valley City Milling Co., Grand Rapids, Mich.							
B 539	Farmers Favorite Middlings with Ground Screenings not exceeding mill run	Spring Lake	*G.	......	15.2	4.5	5.5	....
			*F.	9.8	15.9	5.1	6.7	33 00
B 934	Farmers Favorite Middlings with Ground Screenings not exceeding mill run	Sturgis		10.9	15.6	4.9	4.9	1 50
B 1007	Farmers Favorite Middlings with Ground Screenings not exceeding mill run	Whitecloud		9.6	14.9	4.7	6.3	32 00
		Average		10.1	15.5	4.9	6.0	....
	Voight Milling Co., Grand Rapios, Mich.							
B 516	Crescent Middlings	Vriesland	*G.	......	15.0	4.0	8.0	....
			*F.	11.5	16.6	4.8	4.8	$30 00
B 936	Crescent Middlings	White Pigeon		11.3	15.3	4.8	6.2	1 70
B 937	Crescent Middlings	White Pigeon		11.2	13.3	3.2	6.0	1 70
		Average		11.3	15.1	4.3	5.7	....
B 1226	Voight Pure Middlings	So. Haven	*G.	......	14.0	4.0	8.5	....
			*F.	11.4	15.6	4.1	4.2	$1 60
	Walton Milling Co., Lansing, Mich.							
B 95	Middlings	Lansing	*G.	......	......	......	......	....
			*F.	9.0	14.3	4.1	10.4	30 00
B 133	Middlings	Lansing		10.2	13.9	4.7	5.3	1 50
		Average		9.6	14.1	4.4	7.9	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Washburn-Crosby Co., Minneapolis, Minn.							
B 156	Wheat Standard Middlings with Ground Screenings not exceeding mill run	Howell	*G.	......	15.0	5.0	9.5	....
			*F.	9.5	15.8	5.1	8.5	$1 50
B 1227	Wheat Standard Middlings with Ground Screenings not exceeding mill run	So. Haven		9.9	14.5	5.6	6.7	1 50
		Average		9.7	15.2	5.4	7.6	....
B 1031	Wheat Middlings with Ground Screenings not exceeding mill run	Traverse City	*G.	......	14.0	4.0	11.0	....
			*F.	10.6	15.3	4.8	9.1	$27 00
B 1254	Wheat Middlings with ground Screenings not exceeding mill run	Paw Paw		9.0	15.9	5.5	8.0	1 50
		Average		9.8	15.6	5.2	8.6	....
	Watson-Higgins Milling Co., Grand Rapids, Mich.							
B 449	Wheat Middlings	Grand Rapids	*G.	......	......	......	......	....
			*F.	11.0	15.1	4.6	4.5	$29 00
	Yale Milling Co., Yale, Mich.							
B 821	Ground Middlings	Port Huron	*G.	......	......	......	......	....
			*F.	10.1	15.5	3.4	4.2	1 60
	WHEAT MIXED FEEDS.							
	Huron Milling Co., Harbor Beach, Mich.							
B 687	Jenks Wheat Mixed Feed with Ground Screenings not exceeding mill run	Alpena	*G.	......	13.2	4.6	5.9	....
			*F.	9.7	13.5	4.0	7.9	1 40
B 822	Jenks Wheat Mixed Feed with Ground Screenings not exceeding mill run	Port Huron		9.2	14.2	3.9	8.0	1 50
B 838	Jenks Wheat Mixed Feed with Ground Screenings not exceeding mill run	Sandusky		9.3	13.1	3.7	7.8	1 50
B 842	Jenks Wheat Mixed Feed with Ground Screenings not exceeding mill run	Harbor Beach		10.2	15.0	3.8	8.1	1 30
		Average		9.6	14.0	3.9	8.0	....
	Chas. A. Krauso Milling Co., Milwaukee, Wis.							
B 519	Badger Fancy Mixed Feed	Forest Grove	*G.	......	12.5	4.0	9.0	....
			*F.	9.4	13.1	5.3	4.2	$31 00
	Peninsula Milling Co., Flint, Mich.							
B 853	Wheat Mixed Feeds	Flint	*G.	......	15.0	4.0	9.0	....
			*F.	9.2	14.4	5.4	7.4	1 45
	F. W. Stock & Son, Hillsdale, Mich.							
B 239	Monarch Fancy Wheat Feed with Ground Screenings not exceeding mill run	Jackson	*G.	......	16.0	4.0	10.0	....
			*F.	9.1	15.9	4.8	7.8	1 50
B 921	Monarch Fancy Wheat Feed with Ground Screenings not exceeding mill run	Hillsdale		11.1	15.5	4.7	7.9	24 00
		Average		10.1	15.7	4.8	7.9	....
B 922	Superior Wheat Feed and Flour	Hillsdale	*G.	......	16.0	4.5	7.0	....
			*F.	10.2	14.2	3.9	6.5	$26 00
	Valley City Milling Co., Grand Rapids, Mich.							
B 474	Farmers Favorite Cow Feed	Grand Rapids	*G.	......	16.8	4.4	7.9	....
			*F.	9.5	14.7	4.8	8.8	....
	Washburn-Crosby Co., Minneapolis, Minn.							
B 99	Wheat Bran & Middlings	Benton Harbor	*G.	......	17.0	5.0	16.0	....
			*F.	9.5	16.3	4.9	5.5	1 60

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	WHEAT AND RYE MIXED FEEDS.							
	Northern Milling Co., Wausau, Wis.							
			*G.	......	16.0	4.0	3.0	....
B 718	Wheat and Rye Red Dog	Crystal Falls	*F.	11.0	15.7	4.3	1.8	$2 00
	Cereal Mills Co., Wausau, Wis.							
			*G.	......	15.0	5.0	8.0	....
B 729	Wheat and Rye Middlings	Iron River	*F.	9.7	16.5	4.3	5.1	1 50
	RYE MIDDLINGS.							
	Commercial Milling Co., Detroit, Mich.							
			*G.	......	14.0	2.0	4.5	....
B 315	Rye Middlings	Detroit	*F.	9.6	15.4	3.1	4.8	14 50
	Norvell Roller Mills.							
			*G.	......	......	......	......	....
B 275	Fancy Rye Middlings	Jackson	*F.	11.1	14.3	2.8	3.9	26 00
	David Stott Milling Co., Detroit, Mich.							
			*G.	......	......	......	......	....
B 331	Coarse Rye Middlings	Detroit	*F.	12.9	10.3	1.5	2.0	1 40
	OAT MIDDLINGS.							
	Beck Cereal Co., Detroit, Mich.							
			*G.	......	......	......	......	....
B 284	Coarse Oat Middlings	Detroit	*F.	6.6	13.8	5.1	15.7	80
			*G.	......	......	......	......	....
B 285	Fine Oat Middlings	Detroit	*F.	7.4	16.6	7.8	......	1 40
B 289	Fine Oat Middlings	Detroit		7.4	16.6	7.8	17.4	1 55
		Average		7.4	16.6	7.8	17.4	....
	BARLEY BRAN.							
	Postum Cereal Co., Battle Creek, Mich.							
			*G.	......	6.0	1.3	32.0	....
B 1256	Barley Bran	Paw Paw	*F.	8.1	12.7	2.5	14.1	$1 30
B 1278	Barley Bran	Battle Creek		7.5	12.3	3.2	11.9	18 00
		Average		7.8	12.5	2.9	13.0	....
	CEREAL FOOD BY-PRODUCTS.							
	Grain Products Co., Battle Creek, Mich.							
			*G.	......	......	......	......	....
B 1302	Corn Flakes Residuum	Battle Creek	*F.	7.5	7.9	0.7	1.0	$1 10
			*G.	......	......	......	......	....
B 1303	Wheat Flakes Residuum	Battle Creek	*F.	5.5	16.6	6.0	4.3	1 10
	Kellogg Toasted Corn Flake Co., Battle Creek, Mich.							
			*G.	......	6.9	2.2	0.4	....
B 667	Dried Corn Flake Feed	Adrian	*F.	7.2	7.8	2.0	0.7	28 00
B 681	Dried Corn Flake Feed	Tecumseh		8.0	8.1	2.0	0.9	1 50
B 1273	Dried Corn Flake Feed	Battle Creek		7.5	7.0	1.1	0.9	24 00
		Average		7.6	7.6	1.7	0.8	....
			*G.	......	......	......	......	....
B 1308	Bran Sweepings	Battle Creek	*F.	4.2	13.8	0.6	1.1	$1 00
			*G.	......	9.4	0.4	2.4	....
B 1271	Broken Wheat Biscuit	Battle Creek	*F.	5.0	13.5	1.8	3.7	25 00
			*G.	......	......	......	......	....
B 1307	Floor Sweepings	Battle Creek	*F.	8.6	15.1	3.5	4.5	1 00
			*G.	......	......	......	......	....
B 1311	Granola Siftings	Battle Creek	*F.	5.6	16.1	3.9	7.3	1 30
			*G.	......	......	......	......	....
B 1305	Middlings By Product	Battle Creek	*F.	11.1	12.1	2.2	1.4	1 30
			*G.	......	......	......	......	....
B 1306	Screenings	Battle Creek	*F.	11.3	11.6	2.2	2.5	1 00

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1915-1916.—Concluded.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Mapl-Flake Mills, Battle Creek, Mich.							
B 1282	Mapl-Flake Feed	Battle Creek	*G.	......	12.0	4.0	6.0	....
			*F.	6.5	12.2	4.5	4.5	$25 00
	Postum Cereal Co., Ltd., Battle Creek, Mich.							
B 1276	Cereal Feeding Stuff	Battle Creek	*G.	......	11.0	1.8	18.0	....
			*F.	4.2	12.6	2.8	11.5	10 00
B 1281	CXX Feed	Battle Creek	*G.	......	15.0	2.0	24.0	....
			*F.	6.2	17.6	3.8	19.2	9 50
B 850	CXX Feed	Birch Run		6.5	18.8	4.2	17.7	1 35
B 1255	CXX Feed	Paw Paw		8.2	18.4	3.8	17.8	85
		Average		7.0	18.3	3.9	18.2	....
B 256	Flaked Corn Feed	Jackson	*G.	......	8.0	1.0	5.0	....
			*F.	12.0	9.8	0.6	0.6	$1 25
B 654	Flaked Corn Feed	North Adams		6.5	7.9	0.4	0.7	1 40
B 658	Flaked Corn Feed	Hudson		6.3	11.0	1.5	1.0	1 40
B 659	Flaked Corn Feed	Hudson		5.6	7.9	0.5	0.7	....
B 1251	Flaked Corn Feed	Paw Paw		6.8	7.6	0.4	0.6	1 45
B 1275	Flaked Corn Feed	Battle Creek		5.8	8.3	0.5	1.0	23 80
		Average		7.2	8.8	0.7	0.8	....
B 1248	G-N Feed	Paw Paw	*G.	......	9.0	1.0	2.5	....
			*F.	5.5	11.0	1.2	1.6	$1 45
B 1279	G-N Feed	Battle Creek		6.5	10.6	1.1	1.3	25 00
		Average		6.0	10.8	1.2	1.5	....
B 1277	Special Feeding Stuff	Battle Creek	*G.	......	9.0	0.5	0.8	....
			*F.	9.8	10.5	0.8	0.3	$26 00
	MISCELLANEOUS FEEDS.							
	Michigan Cereal Co., Port Huron, Mich.							
B 684	Pea Bran	Port Huron	*G.	......	14.0	1.2	36.0	....
			*F.	7.4	17.3	1.1	34.1	....
	Molasses Co. Ltd. London, England.							
B 319	Molasses Meal	Detroit	*G.	......	7.0	......	7.0	....
			*F.	15.4	9.1	0.7	5.5	....

*Abbreviations for Guaranteed and Found.

FEEDING STUFFS LICENSED FOR YEAR ENDING APRIL 1, 1917.

A number of requests come to the office of the Chemist for information as to what feeds may legally be sold and to supply this information a list of such feeds together with the guaranteed analysis of each is given in the following pages.

The list comprises 396 brands, representing 155 manufacturers and is complete at the time of going to press. Failure to find a particular brand in this list indicates one of two things; either the feed is not licensed or has been licensed after this bulletin was printed. In either case it would be advisable to write to the Chemist in Charge for information as to the status of the feed.

	Crude protein.	Crude fibre.	N-free extract.	Ether extract.
American Hominy Co., Indianapolis, Ind.				
Homcoline Feed	17.00	7.00	53.00	5.00
Homco Hominy Feed	10.00	7.00	58.00	6.00
American Linseed Co., New York, N. Y.				
Old Process Linseed Oil Meal	34.00	9.00	42.00	6.00
American Maize-Products Co., 135 William St., New York, N. Y.				
Cream of Corn Gluten Feed	24.00	8.50	....	1.50
American Milling Co., Peoria, Ill.				
Amco Dairy Feed	25.00	14.00	30.00	....
Amco Fat Maker	10.00	12.00	50.00	....
Amco Old Process Linseed Meal	30.00	10.00	30.00	....
Cluck Cluck Scratch Feed	10.00	5.00	65.00	....
Cluck Cluck Scratch Feed with 5% Grit	10.00	5.00	65.00	....
Sucrene Calf Meal	20.00	3.00	55.00	....
Sucrene Chick Feed	10.00	5.00	65.00	....
Sucrene Dairy Feed	16.50	12.00	46.00	....
Sucrene Hog Meal	16.00	10.00	46.00	....
Sucrene Horse Feed (with Alfalfa)	10.00	12.00	50.00	....
Sucrene Poultry Mash	18.00	9.00	50.00	....
Sucrene Scratch Feed	10.00	5.00	65.00	....
Sucrene Scratch Feed with 5% Grit	10.00	5.00	65.00	....
Tip Top Alfalfa Horse Feed	10.00	12.00	50.00	....
Tip Top Scratch Feed	10.00	5.00	70.00	....
Tip Top Scratch Feed with 5% Grit	10.00	5.00	70.00	....
Arcady Farms Milling Co., 208 So. La Salle St., Chicago, Ill.				
(RKD) Arcady Calf Meal	25.00	7.00	50.00	5.00
(RKD) Arcady Certified Dairy Feed	18.00	15.00	60.00	3.50
(RKD) Arcady Dairy Feed	16.00	15.00	60.00	3.50
(RKD) Arcady Horse Feed	9.00	12.00	65.00	1.50
Archer Daniels Linseed Co., Minneapolis, Minn.				
Old Process Ground Oil Cake	32.00	10.00	....	6.00
Armour Fertilizer Works, Chicago, Ill.				
Armour's Blood Meal	80.00	2.00	....	....
Armour's Granulated Bone	23.00	2 00	....	....
Armour's Meat Meal	60.00	2.00	....	6.00
Atlas Feed & Milling Co., Peoria, Ill.				
Atlas Distillers' Grains	30.00	14.00	30.00	11.00

FEEDING STUFFS LICENSED FOR YEAR.—Continued.

	Crude protein.	Crude fibre.	N-free extract.	Ether extract.
Bad Axe Grain Company, Bad Axe, Mich.				
"Axe Brand"	10.85	8.96	65.01	3.10
Egg Brand	10.24	4.80	70.09	2.70
Molasses Feed	10.86	19.27	50.76	2.99
The Wm. Bacon Holmes Co., Chelsea, Mich.				
Phoenix Chick Feed	9.00	5.00	....	2.50
Phoenix Scratch Feed	10.00	5.00	....	2.50
J. J. Badenoch Co., Chicago, Ill.				
Badenoch C & O Chop	9.00	12.00	....	3.00
C-er-lay Fine Chick Feed	9.50	5.00	60.00	2.50
C-er-lay Poultry Feed	9.50	5.00	45.00	2 50
Daily Egg Poultry Feed	9.50	5.00	45.00	2.50
Eg-a-day Meat Cereal Mash	15.00	8.00	45.00	4.00
Gloskoat Horse Feed	10.00	12.00	....	2.00
Graingold Horse & Cattle Feed	10.00	12.00	....	2.00
Kumboss Dairy Feed	10.00	25.00	....	5.00
Sunflower Fine Chick Feed	10.00	5.00	60.00	2.50
Sunflower Poultry Feed	10.00	5.00	60.00	2.50
E. I. Bailey, Cleveland, Ohio.				
"Pearl" Hominy Feed	9.00	7.00	....	7.00
Dwight M. Baldwin, Jr., Minneapolis, Minn.				
Baldwin Flour Mills Wheat Bran with not exceeding mill run of ground screenings	14.50	12.00	....	4.00
Baldwin Flour Mills Wheat Flour Middlings with not exceeding mill run of ground screenings	16.50	7.00	....	5.00
Baldwin Flour Mills Wheat Shorts with not exceeding mill run of ground screenings	15.00	11.00	....	5.00
The J. E. Bartlett Co., Jackson, Mich.				
Bartlett's Farmer Brand Cold Pressed Cottonseed Cake	23.00	27.00	25.00	7.00
Bartlett's Farmer Brand Hominy Feed	9.50	7.00	....	7.00
Bartlett's Jersey Farmer Brand Prime Cottonseed Meal	38.50	12.00	24.00	6.00
Bartlett's Michigan Farmer Brand Choice Cottonseed Meal	41.00	10.00	20.00	7.00
Bartlett's National Gluten Feed	31.00	13.00	40.00	12.00
Bay State Milling Co., Winona, Minnesota.				
"Winona" Wheat Middlings & Wheat Screenings	15.00	8.00	58.00	5.00
Ferdinand Becker, Grand Rapids, Mich.				
Feed Corn Meal	9.00	5.00	....	4.00
The Beck Cereal Co., Detroit, Mich.				
Royal Chop Feed	8.31	5.81	....	....
Blatchford Calf Meal Factory, Waukegan, Ill.				
Blatchford's Calf Meal	24.00	6.75	....	5.00
Blatchford's Dairy Brand Calf Meal	19.00	6.50	....	5.00
Blatchford's Dairy Meal with Alfalfa	17.50	18.00	....	5.00
Blatchford's "Fill the Basket" Egg Mash	19.00	10.00	....	4.00
Blatchford's Milk Mash	20.00	7.50	....	4.00
Blatchford's Pig Meal	18.00	7.00	....	5.00
William Boardman, Benton Harbor, Mich.				
Success Chicken Feed	9.36	3.45	70.14	3.05
H. P. Boehm Co., Benton Harbor, Mich.				
Star Chicken Grain	10.85	3.20	71.84	3.30
F. W. Brode & Co., Memphis, Tenn.				
Dove Brand Cotton Seed Meal	38.63	12.00	....	6.18
Owl Brand Cotton Seed Meal	41.00	10.00	....	6.50

FEEDING STUFFS LICENSED FOR YEAR.—Continued.

	Crude protein.	Crude fibre.	N-free extract.	Ether extract.
The Buckeye Cotton Oil Co., Cincinnati, Ohio.				
'Buckeye" Cottonseed Meal	38.62	12.00	32.00	6.50
W. J. Byrnes & Co., Chicago, Ill.				
Daisy Chick Feed	10.00	5.00	....	3.00
Jewel Poultry Feed	9.50	5.00	....	2.50
Royal Poultry Feed	10.00	5.00	....	3.00
Callam Mills, Saginaw, Mich.				
Bob White Poultry Feed	9.00	4.00	67.00	3.00
Candee Incubator & Brooder Co., Eastwood, New York.				
Candee Brand Chick Food	19.00	7.50	....	4.00
Caughey Jossman Co., Detroit, Mich.				
CCC Brand Scratch Feed	9.71	3.30	67.54	3.05
CCC Chicken Feed	10.00	5.00	....	2.50
Cereal Mills Co., Wausau, Wis.				
Cemco Hen Feed	9.00	2.50	....	2.00
Corn & Oat Ground Feed	10.00	7.00	....	7.00
Hominy Feed	11.25	4.00	....	8.50
Chapin & Co., Hammond, Ind.				
Ajax Flakes	30.00	14.00	30.00	10.00
Green Diamond Cottonseed Meal	41.00	10.00	25.00	7.00
Lactola Dairy Feed	16.50	8.00	50.00	3.00
Unicorn Dairy Ration	26.00	10.00	50.00	5.50
Cheboygan Flour Mill Co., Cheboygan, Mich.				
Corn Germ Meal	9.44	3.78	....	2.40
Highland Scratch Feed	9.50	5.25	....	3.50
Clinton Sugar Refining Co., Clinton, Iowa.				
Clinton Corn Germ Meal	20.00	12.00	49.00	7.00
Clinton Corn Gluten Feed	23.00	8.00	55.00	3.00
The Collis Co., Clinton, Iowa.				
Plymouth Brand Poultry Food	15.00	6.00	....	4.00
Commercial Milling Co., Detroit, Mich.				
Henkels Chop Feed	8.50	10.00	....	3.50
Henkels Fine White Feed	15.00	6.00	....	7.00
Henkels Coarse Feed Corn Meal	8.50	2.00	....	....
Henkels Poultry Feed with grit	9.00	4.00	57.34	2.40
Waumbeck Feed	7.70	15.00	....	2.00
Wheat Fine Middlings with Ground Screenings not exceeding mill run	15.00	6.00	....	4.50
Standard Wheat Middlings with Ground Screenings not exceeding mill run	13.50	10.00	....	4.50
Continental Cereal Co., Peoria, Ill.				
Continental Gluten Feed	29.00	10.00	....	10.00
The G. E. Conkey Co., C eveland, Ohio.				
Conkey's Buttermilk Starting Food (for chicks)	12.00	4.00	56.00	3.00
Corn Products Refining Co., No. 17 Battery Place, N. Y.				
Buffalo Corn Gluten Feed	23.00	8.50	50.00	1.00
Diamond Corn Gluten Meal	40.00	4.00	40.00	1.00
Diamond Hog Meal	18.00	13.00	42.00	7.00
William G. Crocker, Minneapolis, Minn.				
Wheat Bran with Ground Screenings not exceeding mill run	13.00	13.00	50.00	4.00
Wheat Flour Middlings with Ground Screenings not exceeding mill run	15.00	8.00	55.00	4.00
Wheat Mixed Feed with Ground Screenings not exceeding mill run	14.00	10.00	53.00	4.00
Wheat Standard Middlings with Ground Screenings not exceeding mill run	14.00	11 00	52.00	4.00

FEEDING STUFFS LICENSED FOR YEAR.—Continued.

	Crude protein.	Crude fibre.	N-free extract.	Ether extract.
Cudahy Bros. Co., Cudahy, Wis.				
Badger Brand Blood Meal	80.00	1.00	3.00	.50
Badger Brand Meat Meal	60.00	5.00	1.00	8.00
Badger Brand Poultry Bone	25.00	1.00	3.00	6.00
Darling & Co., Chicago, Ill.				
Darling's Granulated Bone	20.00	3.00	....	.50
Darling's 60% Protein Digester Tankage	60.00	3.00	....	.50
Darling's High Protein Meat Scraps	55.00	3.00	....	.50
Darling's Meat Crisps	75.00	3.00	....	.50
Darling's Standard Meat Scraps	45.00	3.00	....	.50
Darrah Milling Co., Big Rapids, Mich.				
Unbolted Corn Meal	8.75	2.65	65.94	4.81
S. P. Davis, Little Rock, Ark.				
Good Luck Brand Cotton Seed Meal	41.00	10.00	26.00	6.00
Veribest Brand Cotton Seed Meal	38.5	....	24.00	6.00
The Dewey Bros., Blanchester, O.				
Eagle 3D Grains	30.00	13.00	30.00	10.00
The Albert Dickinson Co., Chicago, Ill.				
Alfalfa Meal	12.00	35.00	35.00	1.00
Cero Brand Poultry Feed	10.00	5.00	60.00	2.50
Chico Brand Chick Feed	10.00	5.00	60.00	2.50
Globe Chick Feed	10.00	5.00	60.00	2.50
Globe Developing Feed	10.00	5.00	60.00	2.50
Globe Egg Mash	15.00	10.00	50.00	3.00
Globe Pigeon Feed	10.00	5.00	60.00	2.50
Globe Scratch Feed	10.00	5.00	60.00	2.50
Hobby Horse Feed	9.00	15.00	50.00	1.50
Honeysuckle Feed	10.00	25.00	50.00	.50
King Pigeon Feed	10.00	5.00	60.00	2.50
Oasis Horse Feed	9.00	15.00	50.00	1.50
Pine Tree Scratch Feed	10.00	5.00	60.00	2 50
Queen Poultry Mash	11.00	10.00	60.00	2.50
Rival Scratch Feed with Grit	9.50	5.00	60.00	2.50
Roseco	10.00	5.00	60.00	2.50
White Cross Chick Feed	10.00	5.00	60.00	2.50
White Cross Horse Feed	10.00	8.00	60.00	2.50
White Cross Scratch Feed	10.00	5 00	60.00	2.50
White Cross Stock Feed	10.00	10.00	60.00	3.50
Donahue Stratton Co., Milwaukee, Wis.				
Wheat Bran with Ground Screenings not exceeding mill run	15.00	11.80	4.80	....
Douglas Company, Cedar Rapids, Iowa.				
Douglas Corn Gluten Feed	23.00	8.00	52.00	1.00
The John P. Dousman Milling Co., DePere, Wis.				
Coarse Bran	15.00	9.00	4.50	....
Fine Middlings	15.00	4.50	9.00	....
Duluth-Superior Milling Co., Duluth, Minn.				
Wheat Flour Middlings	16.50	7.00	....	5.00
Duluth Imperial Bran	14.50	12.25	....	3.75
Wheat Standard Middlings	16.50	7.75	....	4.75
Duluth Universal Milling Co., Duluth, Minn.				
Universal Flour Middlings	17.00	5.10	....	....
Universal Bran	14.60	12.30	....	....
Eagle Roller Mill Co., New Ulm, Minn.				
Wheat Bran with Ground Screenings not exceeding mill run	14.00	11.00	49.00	3.40
Wheat Middlings with Ground Screenings not exceeding mill run	14.20	10.00	55.00	4.40

FEEDING STUFFS LICENSED FOR YEAR.—Continued.

	Crude protein.	Crude fibre.	N-free extract.	Ether extract.
B. A. Eckhart Milling Co., Chicago, Ill.				
Bran & Screenings	14.00	11.00	50.00	4.00
Middlings & Screenings	14.00	7.00	60.00	4.00
East St. Louis Cotton Oil Co., National Stock Yards, Ill.				
East St. Louis Brand C-S Meal	38.50	12.00	....	6.00
Illinois Brand Cottonseed Meal	41.00	12.00	26.00	7.00
Evans Milling Co., Indianapolis, Indiana.				
Evans Hominy Feed	10.00	7.00	....	7.50
Everett, Aughenbaugh & Co., Waseca, Minn.				
E-A-Co Wheat Bran & Ground Screenings	14.00	12.00	....	3.00
E-A-Co Wheat Middlings and Ground Screenings	15.00	10.00	....	3.00
The Famabella Co., Detroit, Mich.				
Common Sense Scratch Feed	9.50	2.50	64.61	2.50
Famabella	14.50	5.00	....	2.50
Farmers Feed Co., New York.				
Bull Brand Dried Brewers Grains	27.20	15.20	41.40	6.30
Feeders Supply Co., Kansas City, Mo.				
Equity Brand Red Tag C-S Meal and Cake	38.62	12.00	....	5.00
The Fleischmann Co., Cincinnati, Ohio.				
The F. Co. and Factory No. 9	21.00	17.00	45.00	9.00
Fleischmann's Dried Grains	19.00	19.00	....	7.00
O. Gandy & Co., South Whitley, Ind.				
Standard A Brand Poultry and Chick Feed	9.50	5.00	....	2.50
Golden Grain Milling Co., East St. Louis, Ill.				
Ben Hur Horse & Mule Feed	10.00	12.00	55.00	2.00
Golden Grain Dairy Feed	14.00	15.00	50.00	2.50
Mascot Horse & Mule Feed	9.00	14.00	55.00	1.50
Wm. O. Goodrich Co., Milwaukee, Wis.				
Old Process Ground Oil Cake	....	10.00	32.35	5.00
Great Northern Flour Mills Co., Minneapolis, Minn.				
Wheat Middlings with Ground Screenings not exceeding mill run	15.00	9.50	52.00	5.00
Hankey Milling Co., Petoskey, Mich.				
Bran with Mill Run of Screenings	13.56	9.57	57.68	3.75
Feed Meal	9.71	3.37	70.24	5.32
Hales & Edwards Co., Chicago, Ill.				
Cackle Fine Chick Feed (with grit and charcoal)	10.00	5.00	60.00	2.50
Cackle Poultry Feed (with Grit Shell and Charcoal)	10.00	5.00	60.00	2.50
Excelsior Horse Feed	10.00	8.00	60.00	3.00
Gold Flake Dairy Feed	16.00	15.00	50.00	3.50
Greeno Feed	10.00	26.00	40.00	.50
Harvest Horse Feed	10.00	15.00	45.00	2.00
Morning Glory Scratch Feed (with Grit Shell and Charcoal)	10.00	5.00	60.00	2.50
Red Comb Alfalfa Meal	13.50	30.00	....	1.00
Red Comb Coarse Chick Feed (with Grit and Charcoal)	10.00	5.00	60.00	2.50
Red Comb Fine Chick Feed (with Grit and Charcoal)	10.00	5.00	60.00	2.50
Red Comb Meat Mash (with Shell and Charcoal)	15.00	8.00	45.00	4.00
Red Comb Poultry Feed (with Shell and Charcoal)	10.00	5.00	60.00	2.50
Red Horn Calf Meal	25.00	6.00	....	5.00
Red Horn Dairy Feed	25.00	15.00	50.00	4 00
Pioneer Feed	10.00	9.00	50.00	2.50
Pound Squab Pigeon Feed (with grit)	10.00	5.00	60.00	2.50

FEEDING STUFFS LICENSED FOR YEAR.—CONTINUED.

	Crude protein.	Crude fibre.	N-free extract.	Ether extract.
The Howard H. Hanks Co., Chicago, Ill.				
Golden Egg Coarse Chick (no Grit)	10.00	5.00	....	....
Golden Egg Fine Chick (with grit)	10.00	5.00	....	....
Kingfalfa Horse Feed	9.00	15 00	....	....
Kukoo Scratch Feed (no Grit)	9.50	5.00	....	....
Kukoo Scratch Feed (with Grit)	9.50	5.00	....	....
Polo Feed	9.00	12.00	....	....
Henderson Milling Co., Grand Rapids, Mich.				
Corn Meal	8.75	1.25	73.16	4.20
Hen's Best Scratch Feed	10.00	5.00	60.00	2.50
Hirst & Begley Linseed Co., Chicago, Ill.				
Hirst & Begley Brand	34.00	9.00	....	6.00
H. M. Hobart & Son, Detroit, Mich.				
P & H Chop Feed	8.75	5.22	69.58	3.92
The Hottelet Co., Milwaukee, Wis.				
Holstein Brewers Dried Grains	25.00	14.00	....	5.00
Hubbard Milling Co., Mankato, Minn.				
Flaky Bran	13.00	13.40	....	4.20
Standard Middlings	15.50	11.20	....	3.50
Humphreys-Godwin Co., Memphis, Tenn.				
Bull Brand Cottonseed Meal	41.00	10.00	26.00	6.00
The Huron Milling Co., Harbor Beach, Mich.				
Jenks Gluten Feed	22.00	.80	....	3.00
Jenks Mixed Feed	12.18	5.85	68.32	4.60
Bert B. Hyde, Port Huron, Mich.				
Ideal Poultry Feed	10.15	2.25	71.38	3.87
Illinois Feed Mills Branch Ralston Purina Co., St. Louis, Mo.				
Feed Well Chick Feed	10.00	5.00	65.00	2.50
Feed Well Scratch Feed	10.00	5.00	65.00	2.50
International Stock Food Co., Minneapolis, Minn.				
International Grofast Calf Meal	25.00	10.00	46.00	5.00
The Interstate Feed Association, Detroit, Mich.				
Interstate Dairy and Hog Feed	16.00	15.00	....	7.00
Mormilk Ready Ration Dairy Feed	23.00	15.00	45.00	5.00
W. J. Jennison Co., Minneapolis, Minn.				
Wheat Bran with Ground Screenings not exceeding mill run	15.00	10.00	....	4.00
J. P. Keeton & Co., Atlanta, Ga.				
"Southern King Brand" Prime Cotton Seed Meal	38.62	10.00	6.18	6.00
Kehlor Flour Mills Co., St. Louis, Mo.				
Rex Middlings	16.00	7.00	....	....
Kellogg Toasted Corn Flake Co., Battle Creek, Mich.				
Broken Wheat Biscuit Feed	10.15	2.60	76.43	1.07
Dried Brewers Grains	25.11	12.75	47.07	5.07
Dried Corn Flake Feed	6.91	.42	78.62	2.15
Invincible Dairy Feed	16.50	6.50	60.00	4.50

FEEDING STUFFS LICENSED FOR YEAR.—CONTINUED.

	Crude protein.	Crude fibre.	N-free extract.	Ether extract.
John B. A. Kern & Sons, Milwaukee, Wisconsin.				
Eagle Wheat Bran with ground screenings not exceeding mill run	14.50	10.00	54.00	3.00
Eagle Wheat Standard Middlings with ground screenings not exceeding mill run	15.00	9.00	53.00	4.50
Chas. A. Krause Milling Co., Milwaukee, Wisconsin.				
Badger Dairy Feed	16.00	15.00	....	3.00
Badger Evergreen Feed	12.00	30.00	....	.50
Badger Horse Feed	10.00	12.00	....	2.00
Badger Stock Feed	10.00	12.00	....	4.50
Badger Fancy Middlings	12.00	7.00	....	4.50
Badger Fancy Mixed Feed	12.50	9.00	....	4.00
Badger Hominy Feed	10.00	5.00	....	6.00
Blue Top Fine Chick Feed (no Grit)	10.00	5.00	....	2.50
Blue Top Fine Chick Feed (with Grit)	10.00	5.00	....	2.50
Blue Top Horse Feed	10.00	16.00	....	1.00
Krause Horse Feed	10.00	10.00	....	2.50
Blue Top Scratch Feed (no Grit)	10.00	5.00	....	2.50
Blue Top Scratch Feed (with Grit)	10.00	5.00	....	2.50
Cream City Horse Feed	10.00	14.00	....	1.50
Cream City Scratch Feed (no Grit)	8.50	5.00	....	2.50
Cream City Scratch Feed with grit	8.50	5.00	....	2.50
The Larrowe Milling Company, Detroit, Mich.				
Brownie Grains (Dried Distillers Grains)	26.00	9.00	40.00	7.00
Larro-Feed	20.00	14.00	50.00	3.00
Larro-Mash	25.00	10.00	44.00	3.00
Log Cabin Scratch Feed	10.00	6.00	....	2.50
Lichtenberg & Son, Detroit, Mich.				
Lichtenberg's Chop Feed	8.00	8.00	60 00	3.00
Lichtenberg's Brand Prime C-S Meal	38.55	12.00	24.00	5.00
Faramel Dairy Feed	23.00	12.00	45.00	4.00
Faramel Horse Feed	10.00	8.00	60.00	3.00
Faramel Brand Wheat Bran with Ground Screenings not exceeding mill run	14.00	10.00	50.00	3.50
Faramel Brand Standard Wheat Middlings with Ground Screenings not exceeding mill run	15.00	10.00	50.00	5.00
Mapl-Flake Mills, Battle Creek, Mich.				
Mapl-Flake Feed	12.00	6.00	66.50	4.00
McMorran Milling Co., Port Huron, Mich.				
Crest Brand Chop	7.00	17.00	58.00	2.00
Protean Dairy Feed	15.00	5.00	65.00	3.00
Crest Brand Poultry Food	8.00	5.00	64.00	2.00
Peak Brand Chick Feed	12.00	5.00	....	2.50
J. M. Macdonald, Cincinnati, Chio.				
Kineda Prime Cottonseed Meal	38.6	12.00	6.18	....
Macado Cottonseed Meal	41.00	12.00	6 59	....
Marinette Flour Mill Co., Marinette Wis.				
Plymouth Rock Every Day Poultry Feed	9.00	5.00	....	2.00
John C. Martin Co., Mineral Point, Wis.				
Martins Calf Feed	26.00	6.00	....	....
Mayflower Mills, Fort Wayne, Ind.				
Mayflower Bran	14.00	10.00	50.00	4.00
Memphis Cotton Hull & Fibre Co., Memphis, Tenn.				
Cyclone Feed Meal	20.00	23.00	38.00	3.00
Menominee River Sugar Co., Menominee, Mich.				
Sugar Beet Molasses	9.36	10.20	58.56	....

FEEDING STUFFS LICENSED FOR YEAR.—Continued.

	Crude protein.	Crude fibre.	N-free extract.	Ether extract.
Metzger Seed & Oil Co., Toledo, Ohio.				
Old Process Oil Meal	30.00	10.00	....	5.00
Michigan Cereal Co., Port Huron, Mich.				
Pea Bran	14.00	36.00	37.00	1.25
Midland Linseed Products Co., Minneapolis, Minn.				
Midland Pure Old Process Ground Linseed Cake	32.00	9.50	36.00	5.00
Morris & Co., Chicago, Ill.				
Big Sixty Meat Meal Digester Tankage	60.00	5.00	....	8.00
National Food Co., Fond du Lac, Wis.				
No-Milk Calf Food	17.25	6.00	....	5.00
The New Century Co. of Michigan, Detroit, Mich.				
Cadillac Scratch Feed	9.50	5.00	....	2.50
New Century Chick Feed	10.00	5.00	60.00	2.50
New Century Scratch Feed	10.00	5.00	60.00	2.50
New Richmond Roller Mills Co., New Richmond, Wis.				
Flour Middlings with Ground Screenings not exceeding mill run	13.00	9.00	....	3.50
W. C. Nothern, Little Rock, Ark.				
Butterfly Brand Cotton Seed Meal	39.00	10.00	6.00	....
Northern Illinois Cereal Co., Lockport, Ill.				
C & O Feed	9.00	12.00	....	....
Northern Milling Co., Wausau, Wis.				
Northern Feed	9.00	8.00	....	3.00
Wheat & Rye Red Dog	16.00	4.00	....	3.00
Northrup King & Co., Minneapolis, Minn.				
Sterling Baby Chick Starter	10.00	5.00	63.13	2.50
Sterling Chick Feed	10.00	5.00	62.99	2.50
Sterling Hen Feed	10.00	5.00	71.65	2.50
Sterling Scratch Feed	10.00	5.00	60.00	2.50
Northern Linseed Oil Co., Minneapolis, Minn.				
Pure Old Process Ground Linseed Cake	33.00	9.00	....	6.00
Northwestern Consolidated Milling Co., Minneapolis, Minn.				
Wheat Flour Middlings with Ground Screenings not exceeding mill run	15.50	6.00	57.00	4.50
Wheat Standard Middlings with Ground Screenings not exceeding mill run	15.00	11.00	53.00	4.50
North Star Feed & Cereal Co., Minneapolis, Minn.				
No. 1 Corn & Oats Feed	8.50	7.00	60.00	3.25
No. 2 Corn & Oats Feed	9.50	7.00	60.00	3.25
The Northwestern Elevator & Mill Co., Toledo, Ohio.				
Wheat Middlings with ground screenings not exceeding mill run	15.00	6.50	....	....
Norvell Roller Mills, Norvell, Michigan.				
Big 4 Dairy Feed	20.25	8.33	....	1.93
Omaha Alfalfa Milling Co., Omaha, Nebr.				
Alfalfa Meal	12.00	30.00	42.00	1.00
Al-Corn-O Horse Feed	10.00	12.00	55.00	2.00
Cream Alfalfa Dairy Feed No. 1	20.00	18.00	35.00	3.00
Green Meadow Dairy Feed	11.00	25.00	48.00	1.00
Peerless Alfalmo Horse Feed	10.00	12.00	55.00	2.00
Perfection Horse Feed	10.00	12.00	55.00	2.00

FEEDING STUFFS LICENSED FOR YEAR.—CONTINUED.

	Crude protein.	Crude fibre.	N-free extract.	Ether extract.
J. G. Peppard Seed Co., Kansas City, Mo.				
Triple-P Poultry Food	10.00	5.00	60.00	2.50
M. C. Peters Mill Co., Omaha, Neb.				
Peters Alfalfa Queen Mills Dairy Feed	17.50	12.00	50.00	3.00
Peters Arab Horse Feed	9.00	15.00	59.00	2.00
Peters Corn Feed Meal	9.00	5.00	60.00	2.50
Peters King Corn	9.00	18.00	50.00	1.50
Peters Lucern Alfalfa Meal	12.00	33.00	35.00	.50
Peters Re-Peter Horse Feed	9.00	18.00	50.00	1.50
Pillsbury Flour Mills Co., Minneapolis, Minn.				
Pillsbury's Durum Wheat Bran with Ground Screenings not exceeding mill run	11.00	14.00	53.00	4.00
Pillsbury's Durum Wheat Standard B Middlings with Ground Screenings not exceeding mill run	12.50	11.00	54.00	4.00
Pillsbury's Wheat A Middlings with Ground Screenings not exceeding mill run	15.00	8.00	55.00	4.00
Pillsbury's Fancy Wheat Mixed Feed with Ground Screenings not exceeding mill run	14.00	10.00	53.00	4.00
Pillsbury's Wheat Standard B Middlings with Ground Screenings not exceeding mill run	14.00	11.00	52.00	4.00
Pillsbury's Wheat Bran with Ground Screenings not exceeding mill run	13.00	13.00	50.00	4.00
Geo. P. Plant Milling Co., St. Louis, Mo.				
(P) Wheat Bran with Screenings not exceeding mill run	15.00	11.00	....	3.00
(P) Wheat Middlings with Screenings not exceeding mill run	17.00	6.50	....	4.00
Portland Milling Co., Portland, Mich.				
Champion Mixed Feed with Ground Screenings not exceeding mill run	13.56	8.47	59.54	3.58
Postum Cereal Co., Ltd., Battle Creek, Mich.				
Cereal Feed	12.00	18.00	52.00	1.75
Chicken Feed	8.00	15.00	55.00	1.00
Cooked Corn Grits	6.00	2.00	70.00	.25
CXX Feed	15.00	26.00	38.00	2.00
Barley Bran	8.00	30.00	50.00	1.25
Flaked Corn Feed	8.00	5.00	75.00	1.00
Flaked Corn Offal	5.00	2.00	75.00	.50
G-N Feed	9.00	2.50	65.00	1.00
Special Feed	9.00	.75	75.00	.50
Prairie State Milling Co., Chicago, Ill.				
Red Crown Scratch Feed no Grit	10.00	5.00	60.00	2.50
Red Crown Scratch Feed with Grit	10.00	5.00	60.00	2.50
Emerald Horse Feed	10.00	12.00	50.00	2.00
Garland Scratch Feed with Grit	10.00	5.00	60.00	2.50
Prairie State Scratch Feed no grit	10.00	5.00	60.00	2.50
Pratt Food Co., Philadelphia, Pa.				
Pratts Baby Chick Food	12.00	3.00	....	2.50
Purina Mills Branch, Ralston Purina Co., St. Louis, Mo.				
Purina Chick Feed	11.00	4.00	65.00	2.50
Purina Chicken Chowder Feed with Charcoal not over 1%	19.00	9.00	56.00	4.00
Purina Cow Chow Feed	24.00	12.00	52.00	5.00
Purina Dairy Feed	20.00	15.00	45.00	3.80
Purina Feed with Molasses	9.30	11.70	59.2	1.70
Purina Scratch Feed	11.00	4.00	65.00	2.50
The Quaker Oats Co., Chicago, Ill.				
American Hen Scratch Grains	10.00	5.00	60.00	2.50
Big Egg Scratch Grains	10.00	5.00	60.00	2.50
Blue Ribbon Dairy Feed	25.00	12.00	46.00	3.50
Golden Sweet Mule Feed	9.00	15.00	58.00	2.00
Green Cross Horse Mixed Feed with Molasses	10.00	12.00	62.00	2.50
Horse Power Feed	10.00	11.00	57.50	2.80
Maz-all Feed	8.00	2.00	62.00	1.40
Old Tavern Scratch Feed	10.00	5.00	60.00	2.50
Pansy Scratch Grains	10.00	5.00	60.00	2.50

FEEDING STUFFS LICENSED FOR YEAR.—CONTINUED.

	Crude protein.	Crude fibre.	N-free extract.	Ether extract.
The Quaker Oates Co., Chicago, Ill.—Concluded.				
Pansy Scratch Grains with Grit	10.00	5.00	60.00	2.50
Quaker Chick Feed	10 00	5.00	60.00	2.50
Quaker Dairy Feed with Molasses	16 00	14.50	50.00	4 00
Quaker Scratch Grains	10.00	5.00	60.00	2 50
Schumacher Calf Meal	18 00	4.00	54.00	8.00
Schumacher Feed	10.00	10.00	62.00	3.25
Schumacher Little Chick Feed	10.00	5.00	60.00	2.50
Schumacher Scratch Grains	10.00	5.00	60.00	2.50
Schumacher Special Horse Feed	9.25	8.00	64.50	3.25
Victor Feed	8.00	12.00	62.00	3.00
White Diamond Feed	8.00	9.00	62.00	3.25
Ralston Purina Co., St. Louis, Mo.				
Regal Scratch Feed	9.00	5.00	65.00	2.50
M. G. Rankin & Co., Milwaukee, Wis.				
Wheat Bran with Ground Screenings not exceeding mill run	14.50	9.50	52.00	4 00
Wheat Middlings with Ground Screenings not exceeding mill run	15.00	8.00	....	4.00
Roberts Cotton Oil Co., Memphis, Tenn.				
Cottonseed Meal	38.63	10.00	....	....
Ryde & Co., Chicago, Ill.				
Rydes Cream Calf Meal	25.00	6.00	....	5.00
Saginaw Milling Co., Saginaw, Mich.				
Red Hen Dry Mash	16.50	10.00	50.00	3.50
Jos. Schlitz Brewing Co., Milwaukee, Wis.				
Schlitz Purity Dried Grains	26.00	16.00	38.00	6.00
Scofield & Son, Jackson, Mich.				
Scofield's Dry Mash	17.41	8.00	53.21	4.83
Shane Bros. & Wilson Co., Minneapolis, Minn.				
Snowball Flour Middlings with Ground Screenings not exceeding mill run	15.00	7.50	53.00	4.00
Standard Middlings with Ground Screenings not exceeding mill run	15.90	10.00	52.00	4.50
Sheffield-King Milling Co., Minneapolis, Minn.				
"Fairybow"	15.00	9.50	....	5.00
"Fancy Brodflake"	13.50	12.75	....	3.50
"Whitehope"	16.00	7.65	....	4.50
The Sherwin-Williams Co., Cleveland, Ohio.				
S-W Linseed Oil Meal	33.00	8.00	....	6.00
Spencer Kellogg & Sons, Inc., Buffalo, N. Y.				
Pure Old Process Oil Meal made from Linseed Cake	33.00	10.00	37.00	5.00
Spratt's Patent (America) Ltd., Newark, N. J.				
Spratt's Ground Meat	43.00	2.00	.70	11.00
Spratt's Poultry Food No. 3	20.00	2.00	60.00	1.75
J. L. & H. Stadler Rendering & Fert. Co., Cleveland, Ohio.				
Stadler's Feeding Tankage	40.00	2.00	....	....
Standard Grain & Milling Co., Holland, Mich.				
Standard Scratch Feed	10.24	3 15	69.26	2.76
Star & Crescent Milling Co., Chicago, Ill.				
Star & Crescent Bran with Ground Screenings not exceeding mill run	15.00	4.00	....	....
Star Middlings with Ground Screenings not exceeding mill run	15.00	4.00	....	....

FEEDING STUFFS LICENSED FOR YEAR.—Continued.

	Crude protein.	Crude fibre.	N-free extract.	Ether extract.
Star of the West Milling Co., Frankenmuth, Mich.				
Special Feed	8.57	8.97	67.27	3.65
Bernhard Stern & Sons, Inc., Atlas Flour Mills, Milwaukee.				
Atlas Wheat Bran, with Ground Screenings not exceeding mill run	12.50	12.00	3.50	....
F. J. Stuart, Pontiac, Mich.				
Stuarts Mixed Chickenfeed	8.66	3.32	71.89	2.85
Swift & Company, Chicago, Ill.				
Swift's Digester Tankage	60.00	3.00	....	6.00
Swift's Meat Scraps	50.00	3.00	....	8.00
L. Teweles Seed Co., Milwaukee, Wis.				
Badger Brand Chicken Feed	10.00	5.00	....	2.55
Thoman Milling Co., Lansing, Mich.				
Thomico Ground Feed	10.00	6.00	....	4.00
Thunder Bay Milling Co., Alpena, Mich.				
Bradford's Chop	8.14	10.60	64.13	4.38
Thunder Bay Scratch Feed	10.85	3.85	67.35	3.05
The Toledo Grain & Milling Co., Toledo, Ohio.				
Camps Red Ball Chick Food	10.00	5.00	60.00	2.50
Camps Red Ball Scratch Feed	10.00	5.00	60.00	2.50
The Toledo Seed & Oil Co., Toledo, Ohio.				
Major Brand Old Process Oil Meal	30.00	10.00	28.00	5.00
The Ubiko Milling Co., Cincinnati, Ohio.				
Fourex (XXXX) Distillers Dried Corn Grains	31.00	13.00	38.00	12.00
Biles Ready Dairy Ration	24.00	9.00	50.00	7.00
Union Seed & Fertilizer Co., New York City.				
American Red Tag Cotton Seed Meal	38.62	11.50	....	6.18
Security Brand Cotton Seed Meal	36.00	14.00	27.00	5.50
The United States Frumentum Co., Detroit, Mich.				
Frumentum Hominy Feed	9.50	7.00	63.00	7.30
Valley City Milling Co., Grand Rapids, Mich.				
Farmers Favorite Bran & Reduced Screenings	12.51	11.05	....	4.38
Farmers Favorite Cowfeed and reduced Screenings	12.71	10.07	....	5.00
Farmers Favorite Middlings and reduced Screenings	12.75	7.50	....	5.25
Wash-Co. Alfalfa Milling Co., Ft. Calhoun, Neb.				
Strong Horse Feed	9.00	25.00	....	2.00
Washburn Crosby Co., Minneapolis, Minn.				
Wheat Bran with Ground Screenings not exceeding mill run	13.00	13.00	50.00	4.00
Wheat Flour Middlings with Ground Screenings not exceeding mill run	15.00	8.00	55.00	4.00
Wheat Mixed Feed with Ground Screenings not exceeding mill run	14.00	10.00	53.00	4.00
Wheat Standard Middlings with Ground Screenings not exceeding mill run	14.00	11.00	52.00	4.00
Watson Higgins Milling Co., Grand Rapids, Mich.				
Perfection Chick Feed	9.00	3.00	....	2.50
Perfection Scratch Feed	10.00	5.00	....	2.50
Watson Bros., Detroit, Mich.				
Excelsior Stock Food	9.28	2.00	54.47	9.55

FEEDING STUFFS LICENSED FOR YEAR.—Concluded.

	Crude protein.	Crude fibre.	N-free extract.	Ether extract.
E. L. Wellman, Grand Rapids, Mich.				
Cottonseed Meal "Feeders Favorite"	38.55	12.00	24.00	6.00
West Branch Flour Mfg. Co., West Branch, Mich.				
St. Car Feed	10.00	5.00	....	5.00
Western Flour Mill Co., Davenport, Ia.				
Black Hawk Bran with Ground Screenings not to exceed mill run	13.10	10.50	50.00	4.50
Western Grain Products Co., Hammond, Ind.				
Chicago Alfalfa Horse & Mule Feed	10.00	15.00	....	2.50
Calumet Scratch Feed, no Grit and with Grit, not over 5%	10.00	5.00	60.00	2.50
Hammond Dairy Feed	16.50	12.00	48.00	3.50
Hammond Horse Feed	12.00	12.00	....	2.80
Hammond Scratch Feed, no Grit and with Grit, not over 5%	10.00	5.00	60.00	2.50
F. I. Williams & Son, North Adams, Mich.				
Williams Calf Meal	15.00	3.50	....	2.50
E. S. Woodworth & Co., Minneapolis, Minn.				
Corn and Oat Feed	8.00	5.00	....	3.00

STUDIES IN THE COST OF MARKET MILK PRODUCTION.

Bulletin No. 277.

That every successful manufacturing enterprise must have some sort of cost accounting system is a matter of common knowledge. It does not necessarily follow that a manufacturer must at all times sell above costs. He may at times sell below costs, and at others he may secure an unreasonably high price; but the average selling price must at least equal the average cost if he is to continue permanently in the business.

Cost accounting on most farms, especially dairy cost accounting, is conducted with considerable difficulty. It would be comparatively easy to find the amount of labor and the cost of digging a ditch of definite width, depth, and length, in a uniform soil of known consistency; or it would be easy to ascertain the labor requirement for plowing an acre of ground. It is comparatively easy to study any business when men are employed throughout the entire day on a single kind of work.

In the dairy enterprise as conducted on most farms, employment is not continuous, and the care of the dairy herd and the milk is a part of doing chores.

The more one studies the dairy business, the more fully he realizes that it is one of the complex farm problems. Even if dairying were complete with production, our statement would be true; but we still have left the even more intricate features of manufacture, transportation, and distribution.

However, milk plays such an important role in feeding the human family, and the dairy industry occupies such a strategic position in the welfare of mankind, that the complexity of the task offers no satisfactory excuse for its evasion. Further, so much has been said and written on the whole subject of cost accounting in general, and on agricultural accounting in particular, that no justification of the work undertaken is necessary.

Some years ago the writer read a paper before the Grand Rapids Milk Producers' Association in which he discussed some factors in the cost of market milk production. The data which he presented had been collected in the college herd and supplemented by numerous estimates. In the discussion which followed, widely differing opinions were voiced. Men who had spent years of their lives in producing milk for the city market could not agree, yet neither could present evidence in support of his belief. At the close of the discussion the speaker, as well as the audience, was convinced that the aggregate of their knowledge as to the cost of producing milk for the city market was very fragmentary and interspersed at frequent intervals with many crude guesses.

When in the fall of 1913 Experiment Station funds became available for properly carrying on an investigation of the Cost of Market Milk Production the interest of the Grand Rapids Milk Producers' Associa-

tion in this subject was recalled, and an offer to begin the work in their territory was met by a cordial acceptance on the part of the milk producers.

MANNER OF OBTAINING DATA.

It will be well to state at the outset just how the data were obtained. During the years 1913 to 1916 twenty-five farmers co-operated in the work. The Field Investigator, Mr. F. T. Riddell, spent his entire time on these twenty-five farms, allowing himself one day per month to each farm and giving such supplementary direction at other times as he found necessary.

On blanks which were provided and conveniently posted, each farmer kept the daily time account, and made record of the receipts and expenditures, and other needed memoranda. During the monthly visit of the investigator he entered these data on his permanent records, and in conference with the farmer obtained such supplementary data as he needed to complete the history of the month's business. Besides completing and posting these items the investigator secured such other first-hand information as was necessary to give complete and accurate records.

In addition to checking and summarizing the farmers' entries, the investigator secured still more accurate information of all dairy operations throughout the entire day spent at the farm. He arose with the farmer in the early morning and with watch in hand literally timed every process carried on in the stable or the dairy. At the close of the day he was able to write down not only the total number of hours of man labor, but was able to say with certainty just how much time had been devoted to the milking process, how much to feeding the herd, how much to cleaning the stable and barn, how much to grooming the cows, and how much had been devoted to the care of the milk and the dairy utensils. Further, he had taken cognizance of all feeds supplied to the herd during the day, and had made accurate weighings of the same. The data thus secured were used as a check on those recorded by the farmer, and wherever the farmer's data seemed inaccurate or too fragmentary, those obtained by the investigator during his random day were used as the basis for monthly computation.

WHAT DATA WERE OBTAINED.

To the end that the reader may not be confused by the mass of figures which it is found necessary to present, some preliminary explanation and discussion of the data and their classification and arrangement is deemed advisable.

It must be constantly borne in mind by the reader that the subject of our inquiry was the cost of producing milk for the city market.

On all of the farms where the investigations were carried on the production of milk was only one of the enterprises of the farm. On a few of them it was practically the sole enterprise, and crops were grown simply to feed the herd. On other farms milk production was coupled with grain, vegetables, live stock, or fruit production for the market. None of these other enterprises were considered in any manner.

Each farm was conducted in accordance with the farming scheme of

the owner or the operator. The entire list might be considered as representing a fair average of the farms contributing to the city's supply. Possibly the farms studied were a little above the average because on the very small farm or the farm of a very small dairy, the labor incident to dairy production and management is not well defined and could be studied with less convenience and accuracy.

If the problem of analyzing and arranging the necessary data were submitted to several accountants or to several economists with a request for each one to arrange the same in the manner that suited him best, we would not expect these arrangements to be identical or even to agree in many minor points. All, however, would doubtless concede that any single necessary expenditure incident to milk production could be charged under some one of the eleven classes of expenditures given below.

For the sake of clearness, brief comment is made under each heading.

EXPENDITURES.

1. Man Labor.

This item includes all labor performed in any capacity in the care of the herd, whether done by the proprietor or his family, or by hired help. The rate of pay allowed for the same was the market price of similar regular labor on the farm under investigation or in the neighborhood.

2. Horse Labor.

This might possibly be better expressed by the title "Hauling Milk and Incidental Horse Labor," because the cost of the milk was determined as being delivered into the city of Grand Rapids. The hauling price in many sections was 2c per gallon, but actual cost is included in each instance. Under incidental horse labor there would be charged the use of horses incident to the business management of the dairy enterprise or any other horse labor not elsewhere included.

3. Feed.

(a) Roughage.

This included all hay and fodder, all silage, and for the sake of convenience, all bedding.

(b) Concentrates.

Here are charged all grains or concentrated feeds used, those raised and fed on the farm as well as those purchased.

When feeds were raised on the farm the price at which they would sell in the farmer's barn was allowed. In the case of purchased feeds the cost of hauling was added to the purchase price. Where necessary, the cost of cartage of home grown grains to and from the mill and the cost of grinding was added to the price which the whole grains would bring in the farmer's barn or crib.

(c) Pasture.

To ascertain the cost of pasture was one of the most difficult problems that was encountered, because there are not sufficient transactions in pasture privileges to create a market quotation or set a price. Since the real question in hand was not how much feed did the cows get from the pasture, but how much did the pasture privilege cost the farmer, the following method was adopted:

The pasture land was appraised by a competent committee at its real

or sale value. On this value 5% was allowed as interest on the investment. To this interest there was added the cost of fence up-keep, and the annual taxes. The total of these three items was then equitably distributed among all the different animals grazing in the pasture during the year and so much charged to the dairy herd as was found to be its share.

4. Cash Sundries.

This item included ice, fuel for the heaters, or boilers, gasoline, washing powders, and a considerable variety of small expenses not provided for elsewhere.

5. Veterinary Services and Drugs.

The money actually paid for medical attendance, and for conducting the tuberculin test in accordance with the Grand Rapids City ordinance, was charged to this account.

6. Taxes, Interest and Depreciation on the Herd.

An inventory was made of each herd at the beginning of the year, and any changes in the number of cows were noted by the investigator upon each of his monthly visits.

A few of the herds were composed of pure bred animals. Since the only question under investigation was milk production, these herds were inventoried at such a price as grade cows of equal producing ability could be bought. The average value of the herd throughout the entire year was used as the basis upon which to figure allowances for taxes and interest.

An examination of a large number of tax receipts showed that the farmer paid in taxes assessed against his live stock about 1% of their value annually. For money invested in live stock he should be allowed 6% annual interest.

The question of depreciation is not so easily disposed of. There are many ways in which this problem might be attacked, but after considering many of them the following line of reasoning was adhered to, as representing the case in hand most completely and fairly:

When we consider the average life period of a large number of dairy cows as kept on average farms, we shall find that it is between nine and ten years. It is true that many dairy cows live to be much older, and, in the case of pure bred cattle, some are kept to very old age. But when the several factors which tend to shorten the productive life of a dairy cow; such as udder troubles, abortion, failure to breed, accidents, sickness, etc., are taken into account, it will be found that the average age limit of common cows is nearer nine years than ten years. If this is the case, and the cows freshen for the first time at two years, there would be seven years of actual service in the herd. Since actual losses from death will be considered under another heading, we may use seven years as the working life of a dairy cow.

The average value of 460 cows as taken during the first year's investigation was $82.30. Out of this number (460 cows) 60 were sold for beef during the year, and brought an average price of $50.90. The difference between $82.30 and $50.90, or $31.40, would represent the depreciation on a cow for seven years. The yearly depreciation would, therefore, be one-seventh of $31.40, or $4.49 per cow.

If we express this depreciation in terms of per cent of the value of

the cow, it would amount to 5½% of her value. The critical examination of considerable data on this point persuaded the investigators that 5% of the value of a cow should be allowed yearly for her depreciation, when the actual losses occasioned by the enforced slaughter of animals condemned by the tuberculin test, and the losses by death from other causes, are not included. A summary of the items of taxes, interest, and depreciation on the herd would show: Taxes 1%, Interest 6%, Depreciation 5%, or a total of 12% on the value of the cow.

7. Taxes, Interest, Insurance, Repairs and Depreciation on Buildings.

A committee of three visited each farm during each year, and placed a valuation on so much of the barns, yardage, milk houses, ice houses, and water supply, as was needed for the housing of the dairy herd, the storing of their food, and the care of their product.

It is easily apparent that one should not include in this inventory the farm buildings not used for dairy purposes. Some of the farms studied had very elaborate building equipments and were keeping only small herds of dairy cows. In these instances only so much of the building space was included in the inventory as would reasonably provide for the herd kept.

On the total inventory valuation of this equipped portion of the barns, yardage, milk house, ice house, and water supply, 10% per year was allowed as properly providing for the insurance, taxes, interest, repairs, and depreciation of the same.

It is true that during the time within which these investigations were in progress many of the farmers did not spend 10% of the valuation for these purposes, while others spent considerably more. Expenses for repairs and up-keep of buildings are of necessity intermittent, consequently during the years when such expenses are small some farmers are accustomed to regard their net returns as profits, forgetting that some of their income in chargeable to the year's wear on the buildings.

8. Depreciation on Equipment.

Under the head of Equipment there were included the forks, shovels, brooms, wheel barrows, carts, pails, milk cans, coolers, and all such utensils as were required in the stable or the milk house, to care for the cattle and the barns and to handle and deliver the milk of the herd.

The rate of deterioration on tools and equipment of this class is very high, and milk ordinances and general dairy laws require that milk pails, coolers, and milk cans, be in exceptionally good condition. From considerable data kept it was evident that an allowance of 25% per year is none too high a rate on this kind of equipment.

9. Actual Losses in the Herd from Tuberculosis and from Death from all other Causes.

Such a variety of opinions are met with relative to the real cost to the milk producer of complying with ordinances prescribing compulsory testing of all cows whose milk enters into the city trade, that the investigators kept this information as a separate item.

In compliance with the Grand Rapids ordinance all cows were annually subjected to the tuberculin test. Those reacting were slaughtered under proper inspection, and if the carcasses were passed by the inspector they were sold for beef. Whatever net sum the owner received for the reacting animals was credited to his account and deducted from the in-

ventory value of those particular animals. Whenever a cow died from other causes, and a few did die, the inventory value less the sum received for the hide, was charged to this account.

10. Added Earning Power of the Owner in Excess of that Possessed and Exercised by other Labor.

It was explained under Expenditures, Item No. 1. "Man Labor" that the rate of pay allowed the owner or proprietor, was the same as that for which ordinary help could be secured on the farms of the neighborhood. Obviously this rate does not compensate the owner for his supervising ability, or the added value of his services due to the fact that he as owner possesses a double interest in the outcome of his undertakings. The truth expressed by the old adage "The eye of the master fattens his cattle" is especially applicable to the care of a dairy herd.

On those farms where this sort of supervision and ability was hired and paid for, the portion of the manager's wage which could be charged to this item alone, amounted to 50c per month for each cow in the herd, or $6.00 per cow for the entire year.

11. Added Risk due to Possible Loss of Market.

If the City of Grand Rapids had been able to use as whole milk all the milk produced in its natural milk producing district, this item would be reduced to its minimum; but since there was produced within the district a much larger supply than the city could consume, a considerable portion of the milk produced had to go to market in forms other than as market milk. It was frequently noticed that a milk dealer would secure a farmer's milk supply at a rather low price, telling the farmer that as soon as he improved his stable and herd and had better facilities for cooling and storing the milk, he could pay him a better price for the same. But, after the producer had properly equipped his dairy and asked for the better price which he had a right to expect, he often found that the dealer could not use his milk because he could buy of other beginners at the lower price and tempt them with the never-to-be fulfilled promises.

It was also commonly remarked that the producers who were most active in organizing and promoting the interests of the Milk Producers' Association were most frequently left without a market. Be this as it may, the investigators found that about one-fifth of the surrounding farms lost their market each year and were compelled to sell their cream for buttermaking on the regular butterfat basis. The risk, therefore, that each of these farmers sustained, would be represented by the difference between the price which their product would have brought as whole milk and what it did bring when the cream was sold for buttermaking and the skimmilk used on the farm. If all the milk produced each year had been sold on the butterfat and skimmilk basis it would have brought approximately 70% of the price which it did sell for. The loss of market for a single year amounted, therefore, to 30%, and since it was estimated that this market loss would occur one year out of every five, only $\frac{1}{5}$ of 30%, or 6% should be charged yearly to represent this added risk.

Cost of the Sire.

From considerable data kept at this station, and an examination of much published data, it was concluded that the average cost of bull service, and the average value of calves at birth, or at the time the milk becomes normal, differed but slightly. The averages of a considerable number of those figures showed a difference of less than one dollar per cow per year. In order to allow the farmer and the investigator needed time for less familiar data these two items were allowed to balance.

RECEIPTS.

1. Milk.

All milk produced by the herd throughout the entire year was credited to the receipts. The milk used in the household and that fed to calves, or used for other purposes, was accurately weighed and credited at the price which it would have netted the producer at his milk house.

2. Manure.

It is obvious from what has already been said that the field investigator's time was too thoroughly occupied to permit of weighings being taken of the amount of manure produced.

A large amount of very reliable data has already been published on this point by a number of State Experiment Stations. If we take the average of a number of these and express the results in even tons, we shall find that a cow weighing 1,200 lbs. voids approximately twelve tons of manure in a year. Taking these weights as the standard, the manure product of each herd was ascertained on the basis of the average weight of the cows in the herd.

To place an equitable value on the manure at the barn is not an easy task. After one has examined the best literature on the subject he is even more thoroughly convinced that investigators do not agree as to the best method of approach to the subject. Further, since the food of the animals, the methods of management of the litter, the differences in soils, and the uncertainties of the weather, are factors affecting the value of the manure, it is probably inconsistent to expect such an agreement. Taking into consideration the fact that on most of the farms a very appreciable portion of the manure, was voided on grounds less capable of giving commensurate returns, and in yards and lanes where its collection entailed high labor costs, the investigators concluded that a value of $1.50 per ton for the entire yearly product was equitable. All farmers were therefore charged at this rate.

3. Calves.

From what has been previously stated the reader will know that the enterprise of raising young stock on the farm is in no way included as a part of market milk production. All milk which was used for calf feeding was credited to the milk account at the gallon price which it would have brought at the farmer's milk house. As has already been stated under "Cost of Sire," the value of calves at birth was allowed to offset the bull service charge.

THE DATA.

A. Summarized Data.

To the end that the data may be presented in as plain and simple a manner as possible, four brief, partial summaries will be given first. These will be followed by other tables which show in much greater detail the facts and figures from which the partial summaries are obtained.

Table I which follows, shows the average daily labor requirement per cow when all of the cows on all of the twenty-five farms are considered. The number of cows kept on the different farms varied somewhat from month to month, consequently the average number of cows on all of the farms is used.

Accurate records were kept at each farm of the several barn operations which are necessary in the care of dairy stock. For convenience the time of each operation is expressed in minutes per day.

TABLE I.—AVERAGE TIME REQUIREMENT PER DAY FOR THE CARE OF ONE COW.

Operation.	1914. 459.46 cows. Minutes.	1915. 428.57 cows. Minutes.	Approximate per cent of each.
Milking	16.33	16.14	57%
Feeding	3.85	3.39	12%
Cleaning cows	.35	.38	1½%
Cleaning barns and other care of cattle	4.92	4.95	17%
Care of milk and dairy utensils	2.71	2.88	10%
Incidental labor	.42	.67	2%
Business management	.15	.15	½%
Total	28.73	28.56	100%

The reader will keep in mind the fact that these tables simply report the time actually spent. Some of the farms produced a very high grade of milk, while the product from others could not be rated above medium. Upon some farms more time could have been spent in some of the operations. From data which the writers have collected in other herds it is shown that one minute per day is required to clean a dairy cow in a satisfactory manner.

One may conclude from the above Table that the care of a dairy herd will consume approximately one-half hour of a man's time each day for every member of the herd.

Table II reports the average yearly food supplied to the average cow during the two years 1914 and 1915, together with the actual value for the same.

TABLE II.—AVERAGE YEARLY FOOD REQUIREMENT FOR ONE COW.

Kind of feed.	Pounds consumed.	Value.
Succulent (mostly silage)	7,729	$15 06
Dry roughage including bedding	3,321	14 52
Grain	2,343	27 68
Pasture		7 98
Total cost		$65 24

In the judgment of the investigators the cattle were well fed and as economically fed as local conditions would permit. In a few instances more bedding could have been used.

In studying the expenditures one is not so interested in the total expenses of the several farms, as he is in those comparative figures which enable him to grasp the data and understand their significance with ease.

The data might be so arranged as to compare the several farms or their herd production by using the expenses incurred by producing a gallon of milk as the basis or unit for comparison. Such a basis would suffer from the criticism of being too small and would likewise be an unfamiliar one. A more convenient unit of comparison, and a much more familiar one, is a cow.

In Table III there will be found the average yearly expenditures per cow for the year 1914, and also the same average expenditures for 1915.

Table III shows that the total expenses per cow in the year 1914 were $150.57, and in the year 1915, $150.29. If one examines the table still further it will be noted that the average cost of man labor for one cow was a little less than $30.00 per year, and that milk hauling and other horse labor cost about $15.00 per year,—a total of $45.00 for the entire labor item. It further shows that this average cow consumed feeds to the value of about $65.00. All the other expenditures which are frequently classed as over-head charges, amounted approximately to $40.00.

If we express these three classes of expense in terms of per cent, in round numbers they will show the following proportions:

Labor	30%
Feed	45%
Over-head charges	25%

A comparative study of the two years' expenses, item by item, reveals the fact that the losses from tuberculosis and other death are the least constant of any of the items. The explanation of this variation is that nineteen head of cattle were condemned for tuberculosis during 1914 and seventy-five head during 1915.

TABLE III.—AVERAGE YEARLY EXPENDITURES PER COW, THE TOTAL NUMBER OF COWS AND ALL THE FARMS BEING CONSIDERED.

	1914.	1915.
Total number of farms	25	25
Average number of cows for year	459.46	428.57
EXPENDITURES.		
Man labor	28.68	27.19
Hauling milk and other horse labor including R. R. transportation when necessary	15.54	14.77
Feeds:		
Roughage	31.02	30.38
Concentrates	28.61	26.68
Pastures	8 36	7.66
Cash sundries	1.96	1.77
Veterinary services and drugs	.86	.99
Taxes, interest and depreciation on herd	9.88	9.49
Taxes, interest, insurance and depreciation on buildings	8.72	10.33
Depreciation on barn tools and dairy utensils	.50	.48
Actual losses from tuberculosis and other death	1.95	6.25
Added earning power of owner due to knowledge, experience and interest in excess of that possessed and used by ordinary labor	6.00	6.00
Added risk due to instability of market for product as whole milk, which in single year amounts to 30%, and in one year out of every five years would be 6%	8.47	8.30
Total	$150 57	$150 29

Table IV shows that the average milk yield per cow was 6,928 lbs. during 1914, and 7,156.8 lbs. during 1915. The average gallon price dropped off a little in 1915, so that the value of the average cow's milk in 1914 was $141.35, and in 1915, $139.01. If to these sums we add the manure credits for the respective years, we shall have as the total value of products, $158.80 for the year 1914, and $156.60 for the year 1915. If from each of these two totals we substract the total expenses for each year, as shown in Table III, a net profit of $8.23 per cow will be shown for 1914 and $6.31 for the year 1915.

From Table IV it will be seen that the cost of production per gallon was 15.9 cents in 1914, and 15.39 cents in 1915. The net profit per gallon was a little less than one cent during the first year, and only seven-tenths of a cent during the second year.

TABLE IV.—AVERAGE YEARLY RECEIPTS PER COW, THE TOTAL NUMBER OF COWS AND ALL THE FARMS BEING CONSIDERED.

	1914.	1915.
Total number of farms	25	25
Average number of cows per year	459.46	428.57
RECEIPTS.		
Average pounds of milk produced	6,928.00 lbs.	7,156.8 lbs.
Gallons of milk produced	834.70 gals.	862.3 gals.
Average price per gallon delivered into Grand Rapids	16.90c	16.35c
Value of milk produced	$141 35	$139 01
Credit by manure	$17 45	$17 59
Total value of products per cow	$158 80	$156 60
Net profit per cow	$8 23	$6 31
Cost of production per gallon	15.9c	15.39c
Net profit per gallon	1.0c	.7c
Cost of production and delivery per cwt	$1 916	$1 854

B. Detailed Data.

From the standpoint of logical arrangement the Detailed Data should have been presented first, and following this the summarized data. The reversed order, however, is intended to give the reader a birdseye view of the facts before he examines at greater length the information which the following tables present with the necessary detail.

Table V, besides showing the number of cows on each farm at the beginning of each fiscal year, gives the average number of cows for the entire year; and further, presents the inventory of cows, buildings, and other dairy equipment. In each case the column headed "per farm," gives the total investment for the entire farm, while that headed "per cow," shows the proportionate investment for each member of the herd.

TABLE V.—INVENTORY SHOWING THE INVESTMENT IN DAIRY CATTLE, BUILDINGS AND EQUIPMENT ON TWENTY-FIVE DAIRY FARMS FOR THE YEARS 1914 AND 1915.

Number of farm.	Number of cows at beginning of each year.		Average number of cows for each year.		Investment in dairy cattle.			
	First	Second	First	Second	First year.		Second year.	
	1914.	1915.			Per farm.	Per cow.	Per farm.	Per cow.
1	9	....	8.63	....	$588 00	$68 13	....	....
2	20	13	13.87	7.53	1,350 00	97 33	$432 50	$57 43
3	11	10	9.30	10.18	794 00	85 37	850 00	83 49
4	10	10	9.67	10.38	655 00	67 73	850 00	81 88
5	28	35	30.82	34.76	1,811 00	58 76	2,235 00	64 29
6	16	23	25.78	22.35	1,913 00	74 20	1,760 00	78 75
7	18	....	14.93	....	1,175 00	78 70	....	....
8	33	32	32.91	30.81	2,065 00	62 25	2,350 00	76 28
9	16	16	15.74	14.99	1,735 00	110 22	1,600 00	106 80
10	13	11	11.57	8.15	880 00	76 06	750 00	92 02
11	19	16	17.46	15.04	1,805 00	103 38	1,167 00	77 59
12	17	12	11.27	14.13	1,430 00	126 89	1,220 00	86 34
13	24	16	18.28	13.88	1,895 00	103 66	1,607 00	115 78
14	7	9	7.32	8.13	470 00	64 03	695 00	85 47
15	19	18	18.10	19.99	1,395 00	77 07	1,265 00	63 28
16	20	....	19.10	....	1,435 00	75 13	....	....
17	53	49	51.80	11.83	4,645 00	89 67	980 00	82 84
18	28	28	28.44	28.46	2,440 00	85 80	2,450 00	86 09
19	24	24	18.89	20.50	1,990 00	105 17	1,960 00	95 61
20	10	6	7.64	6.81	750 00	98 22	470 00	69 01
21	20	21	19.81	22.23	1,355 00	68 40	1,715 00	77 14
22	20	17	17.70	18.40	1,430 00	80 79	1,250 00	65 48
23	26	....	26.33	....	2,092 00	79 45	....	....
24	11	12	11.47	11.99	755 00	65 73	728 00	60 72
25	13	12	12.67	11.75	963 00	76 00	933 00	79 40
26	....	21	....	16.58	....	....	1,860 00	112 18
27	....	21	....	25.56	....	....	,680 00	65 72
28	....	11	....	12.56	....	....	760 00	60 51
29	....	31	....	31.58	....	....	2,387 00	75 58
Average	....	....	....	....	....	$82 30	....	$79 12

TABLE V.—INVENTORY SHOWING THE INVESTMENT IN DAIRY CATTLE, BUILDINGS AND EQUIPMENT ON TWENTY-FIVE DAIRY FARMS FOR THE YEARS 1914 AND 1915.—*Concluded.*

Number of farm.	Investment in dairy buildings.				Investment in dairy equipment.			
	First year.		Second year.		First year.		Second year.	
	Per farm.	Per cow.	Per farm.	Per cow.	Per farm	Per cow.	Per farm.	Per cow.
1	$917 00	$106 25			$13 76	$1 59		
2	1,168 00	84 21	$1,165 00	$154 71	19 00	1 37	$17 44	$2 31
3	1,188 00	127 75	1,188 00	116 69	16 72	1 79	18 54	1 82
4	632 00	65 34	632 00	60 88	36 96	3 82	18 32	1 76
5	1,278 00	41 14	1,733 00	49 85	19 88	64	29 84	86
6	2,433 00	94 37	2,433 00	108 81	37 24	1 44	37 38	1 67
7	1,208 00	80 91			12 96	87		
8	1,850 00	56 21	1,850 00	60 05	64 90	1 79	54 00	1 75
9	1,967 00	124 97	1,967 00	131 23	33 76	2 14	48 48	3 23
10	1,671 00	144 43	1,671 00	205 03	19 04	1 65	12 76	1 57
11	1,642 00	94 04	1,656 00	110 11	27 52	1 58	33 12	2 20
12	1,908 00	169 30	1,908 00	135 09	22 44	1 99	28 00	1 98
13	1,400 00	76 59	1,400 00	100 86	26 66	1 44	21 52	1 55
14	1,637 00	223 37	1,637 00	201 35	9 85	1 35	8 24	1 01
15	1,300 00	71 83	1,395 00	69 79	118 35	6 54	96 76	4 84
16	942 00	49 32			43 52	2 28		
17	2,850 00	55 00	2,850 00	240 92	170 56	3 29	68 24	5 77
18	2,595 00	91 25	2,700 00	94 90	30 20	1 06	41 12	1 44
19	1,000 00	52 90	1,000 00	48 78	55 96	2 95	47 20	2 30
20	863 00	112 96	863 00	126 72	16 40	2 15	11 88	1 74
21	2,150 00	108 53	2,500 00	112 46	17 36	88	26 00	1 17
22	1,700 00	96 05	1,700 00	92 39	41 00	2 32	30 84	1 67
23	2,302 00	87 42			35 00	1 33		
24	1,848 00	161 11	1,848 00	154 13	21 80	1 90	23 00	1 92
25	1,633 00	128 88	1,633 00	138 98	15 80	1 25	13 76	1 17
26			1,700 00	120 53			28 00	1 69
27			1,800 00	70 42			30 12	1 18
28			900 00	71 65			17 00	1 35
29			4,500 00	142 49			66 12	2 09
Average		$87 24		$103 28		$2 01		$1 93

In reviewing Table V it will be noted that the average value of the cows for the first year was $82.30 per head, and for the second year $79.12 per head. There is considerable variation in the barn investments. The range of such investment is from $41.14 on Farm No. 5 for the first year to $240.92 on Farm No. 17 for the second year. The average of the housing investment is $87.24 for 1914 and $103.28 for 1915. The investment in housing varied with the size of the herd. For herds of twelve cows or less, it averaged $175.58 per cow; for herds from thirteen to twenty cows, it averaged $94.49; while for those herds above twenty cows, the average was $72.61.

The investment in pails, cans, strainers, coolers, etc., averaged less than $2.00 per cow.

If one expresses these three classes of investment in terms of per cent it would be proximately as follows:

Investment in Cattle	45%
Investment in Buildings	54%
Investment in Equipment	1%

When individual farms are studied a considerable range of investment per cow is noted. This is occasioned by the kind and conditions of the cows; the number, age, and state of repairs of the buildings; and the amount, and condition of the other equipment.

Table VI which follows, gives the taxes, interest, insurance, and depreciation on the cattle, buildings, and other equipment on each of the farms for each year. It also gives in its summary the general per cow average for each of these items. A rather marked variation is noticed in these items when the individual farms are compared. Since these farms were not all of the same class a considerable range is inevitable.

When a comparison is made between the general average for the two years a more stable condition is observed.

TABLE VI.—*CHARGES ON INVESTMENT*, TAXES, INTEREST, INSURANCE AND DEPRECIATION ON INVESTMENT.

Number of farm.	Taxes, interest and depreciation on cattle per herd.		Taxes, interest and depreciation on cattle per cow.		Taxes, interest, insurance and depreciation on buildings per herd.		Taxes, interest, insurance and depreciation on buildings per cow.		Taxes, interest and depreciation on equipment per herd.		Taxes, interest and depreciation on equipment per cow.	
	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.
1	$70 56	....	$8 17	....	$91 70	....	$10 62	....	$3 44	....	$0 40	....
2	162 00	$51 90	11 68	$6 89	116 80	$116 50	8 42	$15 47	4 75	$4 36	34	$0 58
3	95 28	102 00	10 24	10 01	118 80	118 80	12 77	11 67	4 18	4 64	45	46
4	78 60	102 00	8 13	9 82	63 20	63 20	6 53	6 09	9 24	4 58	95	44
5	217 32	268 20	7 05	7 71	127 80	173 32	4 14	4 98	4 97	7 46	16	21
6	229 56	211 20	8 89	9 46	243 30	243 30	9 43	10 89	9 31	9 32	36	42
7	140 96	....	9 44	....	120 80	....	8 09	....	3 24	....	22	....
8	247 80	282 00	7 52	9 15	185 00	185 00	5 62	6 00	16 25	13 50	49	44
9	208 20	192 00	13 22	12 81	196 70	196 70	12 49	13 12	8 44	12 12	53	70
10	105 60	90 00	9 12	11 04	167 10	167 10	14 47	20 50	4 76	3 19	41	39
11	216 60	140 00	12 40	9 30	164 20	165 65	9 40	11 00	6 88	8 28	39	55
12	171 60	146 40	15 13	10 36	190 80	190 80	16 92	13 60	5 61	7 00	49	50
13	227 40	192 84	12 46	13 91	140 00	140 00	7 67	10 09	6 66	5 38	36	39
14	56 40	83 40	7 70	10 26	163 70	163 70	22 36	20 15	2 46	2 06	33	24
15	167 40	151 80	9 24	7 60	130 00	139 50	7 18	6 98	29 59	24 19	1 63	1 21
16	172 20	....	9 01	....	94 20	....	4 93	....	10 88	....	57	....
17	557 40	117 66	10 76	9 95	285 00	285 00	5 50	24 09	42 64	17 06	82	1 44
18	292 80	294 00	10 29	10 33	259 50	270 00	9 12	8 20	7 55	10 28	26	36
19	238 80	235 20	12 64	11 47	100 00	100 00	5 29	4 88	13 99	11 80	74	58
20	90 00	56 40	11 78	8 28	86 30	86 30	11 30	12 67	4 10	2 97	54	43
21	162 60	205 80	8 21	9 26	215 00	250 00	10 85	11 25	4 34	6 50	22	29
22	171 66	144 60	9 70	7 86	170 00	170 00	9 60	9 24	10 25	7 71	58	42
23	251 04	....	9 53	....	230 20	....	8 74	....	8 75	....	33	....
24	90 60	87 36	7 90	7 29	184 80	184 80	16 11	15 41	5 45	5 75	48	48
25	115 56	111 96	9 12	9 53	163 30	163 30	12 90	13 90	3 95	3 44	31	29
26	....	223 20	....	13 46	....	170 00	....	10 25	....	7 00	....	42
27	....	201 60	....	7 89	....	180 00	....	7 04	....	7 53	....	29
28	....	91 20	....	7 26	....	90 00	....	7 16	....	4 25	....	34
29	....	286 44	....	9 07	....	450 00	....	14 25	....	16 53	....	52
General average	....	....	$9 88	$9 49	....	....	$8 72	$10 33	....	....	$0 50	$0 48

The largest item entering into the dairyman's expenditures is feeds and bedding, comprising nearly 45% of the total charges. The amount of feed consumed, and the prices of feeds determine in many cases a profit or loss.

As previously explained, all farm feeds are charged at market price, less the cost of hauling. Farm grains that are hauled to mill for grinding have the actual cost of hauling at farm prices for labor, and cost of grinding, added to the price of feeds. On all purchased feeds the cost of hauling was added to the price of the feeds.

A standard price of $4.00 per ton was charged for silage, except where the quality was very poor. In such cases the price was cut according to quality.

In the year of 1914 roughage was very scarce and high priced in the vicinity of Grand Rapids, while in the year 1915 it was very plentiful and moderate in price. These conditions had a marked effect on the total cost of feeds and the amount fed each year.

Table VII shows the number of tons of feed fed per cow, and the value of the feeds and pasture. In every case the bedding is added to the roughage.

The cost of pasture varied greatly on the different farms, ranging from $2.77 to $15.65 per cow. The rental for the permanent pasture was based on the value of the land; other pasture privileges, such as meadows, were charged according to the amount of feed furnished. The number of acres of pasture, length of pasture season, number of cows per acre, and amount of feed used in supplementing pasture, affect the general charges per cow.

The total charges for feeds and pasture for one year vary in the different herds from $39.27 to $93.54 per cow, or a general average of $65.24.

TABLE VII.—*FEEDS.* AVERAGE NUMBER OF TONS OF ROUGHAGE AND CONCENTRATES FED PER COW PER YEAR, AND THEIR VALUES INCLUDING THE VALUE OF THE PASTURE.

Number of farm.	First year.				Second year.				First year.		Second year.		First year.	Second year.	First year.	Second year.
	Succulent roughage.		Dry roughage and bedding.		Succulent roughage.		Dry roughage and bedding.		Concentrates.				Value of pasture.		Total cost of feeds per cow.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.				
1	4.32	$16 34	.95	$7 83	.....	....	.....	....	.72	$22 21	.....	....	$10 08	....	$56 40	....
2	4.58	17 88	1.64	13 76	3.97	$18 89	3.24	$21 62	.79	30 11	1.37	$39 39	7 42	....	69 17	$79 86
3	3.93	15 26	2.39	30 65	4.38	16 98	2.54	27 17	.92	27 50	.65	19 24	3 66	$7 38	77 07	70 77
4	2.16	7 85	1.76	16 24	3.36	12 88	2.61	16 38	.79	22 85	.81	26 52	7 83	7 22	54 77	63 00
5	2.49	9 26	1.17	12 56	2.12	8 18	1.99	11 88	.38	11 52	.38	12 13	15 34	15 65	48 68	47 84
6	3.98	16 12	1.28	11 23	5.09	20 09	2.05	12 70	.60	17 10	.77	20 93	6 57	5 99	51 02	59 71
7	4.29	15 94	1.67	21 22	.....	....	.....	....	1.70	51 22	.....	....	5 16	....	93 54	....
8	2.47	9 88	.85	9 40	2.53	10 50	1.27	9 57	.86	24 59	.81	23 61	10 62	11 34	54 49	54 02
9	5.73	22 01	1.10	13 75	5.69	22 07	1.68	14 13	1.09	30 17	.26	33 16	6 29	8 35	72 22	77 71
10	3.08	12 32	1.50	15 29	3.63	14 53	1.25	7 31	1.00	25 90	.92	25 63	10 02	10 31	63 53	56 78
11	2.77	10 08	2.26	31 46	5.41	21 64	2.06	21 29	1.06	33 22	.49	16 82	8 94	8 64	83 70	68 39
12	5.28	21 54	1.53	13 89	5.51	21 70	1.38	8 63	1.14	35 43	1.11	33 12	11 97	8 80	82 83	71 45
13	4.57	17 82	1.85	19 96	4.83	19 32	1.58	12 16	1.43	44 46	1.43	43 97	4 61	8 40	86 85	83 85
14	.42	1 12	2.71	25 84	.18	46	3.41	18 10	1.26	38 97	1.37	41 18	8 54	9 78	74 47	69 52
15	5.92	22 28	4.02	10 62	2.96	10 39	1.22	14 30	6.43	45 28	6.66	36 54	3 09	3 01	81 27	64 24
16	2.85	11 28	1.32	9 84	.....		.....	....	2 52	30 29	.....	....	8 29	....	59 69	....
17	2.78	11 13	1.70	30 21	4.08	14 33	2.37	30 58	1.32	38 84	1.62	27 84	7 07	....	87 25	72 75
18	3.58	11 99	1.60	22 66	4.38	16 41	2.50	27 12	.77	23 29	1.05	18 21	10 58	10 54	68 52	72 28
19	4.45	17 25	1.19	8 31	4.61	17 63	1.46	7 17	1.45	44 61	1.19	38 84	6 04	6 20	76 21	69 93
20	4.30	17 18	1.40	25 43	3.52	13 84	1.29	7 38	.89	17 23	.58	18 56	13 82	9 54	63 66	49 42
21	7.41	30 66	.78	8 22	6.38	25 00	1.24	7 59	.54	16 62	.95	26 24	7 19	7 03	62 69	65 86
22	3.99	15 96	1.30	9 76	4.89	18 98	1.49	8 76	1.27	29 10	.88	26 79	8 50	8 15	73 32	62 68
23	3.74	13 43	1.60	13 23	.....	....	.....	....	.18	6 21	.....	....	8 67	....	41 54	....
24	3.40	13 42	1.64	14 15	4.33	14 52	2.18	14 55	.22	12 44	.68	14 17	9 59	9 42	49 60	52 66
25	3.34	12 61	2.53	17 74	3.73	15 91	2.43	24 43	1.20	30 35	.81	27 50	7 10	7 40	66 95	75 30
26	.....	....	.....	....	3.54	12 72	1.34	11 50	.....	....	1.48	48 97	....	4 52	....	77 71
27	.....	....	.....	....	3.53	13 01	1.41	9 87	.....	....	.34	11 50	....	4 89	....	39 27
28	.....	....	.....	....	3.11	11 89	1.94	12 80	.....	....	.76	24 21	....	10 35	....	59 25
29	.....	....	.....	....	5.22	19 64	2.40	20 30	.....	....	1.20	37 91	....	2 77	....	70 63
Average	3.57	$13 99	1.56	$17 03	4.10	$15 73	1.03	$14 65	1.20	$28 61	1.13	$26 68	$8 36	$7 66	$67 99	$64 72

LABOR.

Man Labor.

As already stated the labor on the different dairy farms was done by the owner or operator, assisted by necessary hired help. On the majority of farms the women wash the utensils, but it is conceded that their labor in this capacity is as efficient, if not more so, than man labor. Very little child labor was used.

For a comparative study, labor was divided as follows: Time feeding, cleaning barns and care of cows, milking, care of milk and cleaning utensils, business management, and incidental labor. Only the actual time spent in performing these operations was considered. Table VIII shows the average time spent on each farm per cow for one year and the cost. The average time spent per cow for the year 1914 was 175.1 hours, and for the year 1915, 175.4 hours.

The price of labor per hour was based on what the monthly laborer received for his services, plus board when boarded by the employer. The farm laborer received from $25.00 to $30.00 per month plus board, which was figured at $3.00 per week.

In determining the labor cost per hour, actual time spent in the dairy was considered. The ten hour day was used as a basis. The average price of man labor per hour for 1914 was 16.38 cents, and for 1915, 15.49 cents; and the average cost of labor per cow per year was $28.68 for the year 1914, and $27.19 for the year 1915.

Horse Labor.

Only such horse labor as was actually spent in the dairy business was considered; namely, time spent hauling milk, feeds, and incidental labor. All horse labor was charged at ten cents per hour per horse. For convenience the cost of the incidental horse labor was added to the cost of hauling the milk, and the cost of all horse and man labor spent in hauling feeds was added to the price of the feed.

Table VIII which follows, contains a record of the time occupied in performing the several operations in the care of the herd. These data are presented on the basis of the care of one cow for the entire year.

TABLE VIII.—*LABOR.* AVERAGE TIME SPENT IN CARING FOR ONE COW FOR ONE YEAR ON EACH DAIRY FARM TOGETHER WITH COSTS OF THE SAME.

Number of farm.	Average number cows fed on each farm.		Average number hours feeding per cow per year.		Average number hours cleaning barns and caring for cows per cow per year.		Average number hours cleaning cattle per cow per year.		Average number hours milking per cow per year.		Average number hours per cow per year in care of milk and cleaning utensils.	
	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.
1	8.63	....	22.0	....	27.0	....	....	....	108.3	....	21.4	....
2	13.87	7.53	31.8	29.6	38.9	37.7	....	....	98.6	75.3	17.8	13.9
3	9.36	10.18	38.3	28.0	28.8	33.4	1.2	24.5	114.5	124.9	20.8	23.8
4	9.67	10.38	28.2	28.4	33.3	28.6	.7	....	92.6	101.1	20.4	25.5
5	30.82	34.76	12.7	11.6	22.5	15.7	1.1	....	61.8	86.7	6.9	9.0
6	25.78	22.35	28.8	27.0	27.4	35.5	4.3	24.6	90.0	108.2	29.4	16.2
7	14.93	....	26.8	....	35.4	....	1.1	....	114.9	....	16.9	....
8	32.91	30.81	17.0	15.5	31.5	24.7	....	....	94.7	87.4	10.7	10.8
9	15.74	14.99	24.9	25.3	26.5	31.8	10.5	7.6	119.8	121.2	17.3	22.2
10	11.57	8.15	26.3	24.8	26.1	25.2	1.5	....	85.5	83.2	22.7	20.3
11	17.45	15.04	16.3	18.7	26.3	33.9	2.5	2.7	105.8	112.2	18.7	25.5
12	11.27	14.13	39.8	24.8	55.7	40.4	10.0	8.1	118.7	107.2	23.9	23.4
13	18.28	13.88	35.3	41.4	35.9	35.5	8.9	5.0	129.8	122.6	13.9	17.4
14	7.32	8.13	25.3	19.7	37.3	29.6	.4	1.5	65.6	71.8	29.2	25.2
15	18.10	19.99	13.0	21.7	31.2	30.7	1.2	1.1	119.9	110.4	25.1	27.4
16	19.10	....	25.6	....	29.6	....	2.4	....	99.5	....	15.0	....
17	51.80	11.83	23.6	32.7	35.5	33.7	2.1	.6	121.7	146.2	13.9	13.0
18	28.44	28.46	20.1	19.1	24.1	26.6	....	....	80.6	86.5	11.5	14.0
19	18.89	20.50	22.1	18.7	30.0	24.4	2.7	1.7	101.9	102.4	14.3	12.5
20	7.64	6.81	34.6	23.2	40.2	43.0	....	1.2	110.2	103.8	24.3	25.8
21	19.81	22.23	20.5	20.6	22.9	18.1	1.8	.6	82.5	104.7	10.4	9.8
22	17.70	18.40	20.7	15.2	30.1	32.4	1.6	1.9	91.5	84.0	20.7	16.8
23	26.33	....	13.0	....	18.3	....	....	....	87.9	....	13.7	....
24	11.47	11.99	17.4	17.8	23.2	32.7	....	....	70.8	96.6	16.2	25.8
25	12.67	11.75	20.2	21.6	17.5	18.6	....	....	119.7	114.7	17.1	12.0
26	....	16.58	....	16.5	....	34.8	....	1.8	....	118.4	....	10.8
27	....	25.56	....	14.9	....	31.8	....	....	....	88.9	....	9.9
28	....	12.56	....	15.1	....	18.0	....	1.4	....	74.5	....	19.5
29	....	31.58	....	24.3	....	49.4	....	35.0	....	94.8	....	35.0
Average	....	....	23.4	20.59	29.9	30.1	2.1	2.3	99.2	99.8	16.5	17.5

TABLE VIII.—*LABOR*.—*Concluded*.

Number of farm.	Average number hours per cow per year in business management.		Average number hours incidental labor per cow per year.		Total number hours man labor per cow per year.		Price of labor per hour.		Average cost of man labor per cow per year.	
	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.
1	1.6	.....	1.6	.....	182.9	.....	$0.163	.....	$29 81	.....
2	1.6	2.3	.6	11.3	188.3	170.3	159	$0 136	29 96	$23 10
3	1.3	1.4	1.3	2.5	206.2	216.2	157	141	32 38	30 53
4	.9	3.8	1.9	1.4	178.0	185.9	161	154	28 67	28 68
5	1.9	3.2	1.4	.7	108.3	124.5	169	153	18 30	19 04
6	1.6	6.7	.2	1.6	181.7	191.6	162	152	29 44	29 15
7	1.9	.....	4.1	.....	201.0	.....	162	.....	32 55	.....
8	.2	3.2	.6	1.0	154.7	139.7	174	170	26 91	23 79
9	2.7	1.9	4.0	2.7	205.7	214.9	172	149	35 40	32 08
10	1.5	1.8	4.5	3.9	168.1	159.2	161	154	27 14	24 49
11	.9	.6	2.4	1.3	172 9	194.3	181	171	31 30	33 34
12	2.0	1.6	5.7	7.7	255.8	212.8	157	143	40 18	30 51
13	2.1	1.2	3.1	7.3	229.0	230.2	157	142	36 02	32 78
14	5.1	2.2	2.5	2.3	165.8	143.1	163	166	27 03	25 32
15	1.7	3.1	5.9	.5	218.0	196.0	159	156	34 67	30 21
16	1.2	.....	2.3	.....	185.6	.....	156	.....	28 93	.....
17	.6	.9	3.1	44.5	200.5	274.9	160	150	32 09	41 25
18	2.1	.5	1.6	1.1	140.0	147.8	168	156	32 51	23 00
19	1.4	1.1	5.1	1.3	177.8	162.5	185	164	32 90	26 65
20	4.2	3.7	10.0	6.3	223.5	206.0	153	143	34 17	29 44
21	.4	.....	.4	.9	138.9	154.3	160	141	22 22	21 73
22	4.7	1.7	4.0	2.3	173.3	154.0	164	150	28 39	23 16
23	.3	.....	1.3	.....	134.5	.....	157	.....	21 13	.....
24	1.5	3.3	.4	1.0	129.5	176.0	161	150	20 87	26 37
25	.8	.3	4.1	1.9	179.4	169.1	165	165	29 61	27 94
26	.....	1.6	.....	2.4	.....	185.6	.....	163	.....	30 17
27	.....	.1	.....	2.8	.....	150.2	.....	157	.....	23 60
28	.....	.....	.....	.6	.....	130.2	.....	139	.....	18 35
29	.....	.5	.....	7.5	.....	220.0	.....	169	.....	37 14
Average	1.5	.9	2.5	4.1	175.1	175.4	$0 1638	$0 1549	$28 68	$27 19

Inasmuch as Table I presents a summary of Table VIII further comment is unnecessary at this point.

Those expenditures which have not already been presented are grouped in Table IX. Many of these items could be classed as overhead charges. They comprise the cash sundries, payments for medical attendance, losses from tuberculosis, and charges for other risks sustained, or services rendered by the producer, which have not already been provided for.

The last four columns of Table IX are summaries of all items of expenses as shown in Tables V., VI., VII., VIII., and IX.

For an explanation and general discussion of the data comprising Table IX., the reader is referred to sub headings 4-11 inclusive under the general outline of expenditures presented on pages 6-8. The only items which need further explanation are those headed "Losses from Tuberculosis and Other Death."

During 1914 nineteen cows were condemned for tuberculosis. Their total inventory value was $1,475.00. From the sale of their carcasses there was received $971.40. The difference of these two numbers, or $503.60, represents the loss on account of tuberculosis during the year, an average of $26.50 for each animal so condemned.

During 1915, seventy-seven cows reacted to the tuberculin test in the twenty-five herds under investigation. The total inventory value of the entire seventy-seven was $6,107.30. Such of these as passed inspection were sold as food, the remainder were utilized for tankage. The receipts from these two sources, together with the money received as state award for such slaughter, amounted to $4,180.45. This sum taken from the inventory value, leaves a total net loss for the year of $1,926.85 in all herds, an average of $25.02 for each condemned animal.

The total number of deaths was six for 1914, and sixteen for 1915. The net death losses for 1914 were $389.75, and for 1915 $750.00. By net death losses is meant the actual losses to the owner when receipts from hide and from insurance, if any, have been deducted from the inventory value of the animal.

If one were to compute from the foregoing data the per cent of risk on the value of the herd as shown by the records of these two years, and the cows actually under observation, it would stand as follows:

Allowance on account of compulsory tuberculin test..
......................3.4% of inventory value of herd.
Allowance for net losses from death..................
......................1.6% of inventory value of herd.

The total of these two items could be approximately represented by 5% of the value of the herd.

TABLE IX.—*OTHER EXPENDITURES.* CASH SUNDRIES, VETERINARY SERVICES, LOSSES DUE TO TUBERCULOSIS AND OTHER DEATHS. ADDED EARNING POWER AND ADDED RISKS PER HERD AND PER COW ON EACH DAIRY FARM FOR TWO YEARS.

Number of farm.	Cash sundries for herd.		Cash sundries per cow.		Veterinary services for herd.		Veterinary services per cow.		Losses from tuberculosis and other deaths per herd.		Losses from tuberculosis and other deaths per cow.	
	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.
1	$17 33	.....	$2 01	.....	$5 15	.....	$0 60	.....	.....	.....	.....	.....
2	41 32	$23 52	2 97	$3 12	4 45	$8 00	32	$1 06	$115 75	$195 50	$8 34	$12 97
3	16 52	11 90	1 77	1 17	7 05	12 85	75	1 26	.....	.....	.....	.....
4	9 18	7 88	95	76	8 75	22 75	90	2 19	.....	53 90	.....	5 19
5	57 00	29 82	1 85	86	18 50	22 35	60	64	.....	.....	.....	.....
6	42 53	24 65	1 64	1 10	6 50	9 05	25	41	.....	.....	.....	.....
7	14 48	.....	97	.....	19 85	.....	1 32	.....	.....	.....	.....	.....
8	19 54	16 04	59	52	18 65	19 95	57	65	.....	67 00	.....	2 17
9	29 14	51 76	1 84	3 45	8 70	12 20	55	71	.....	166 50	.....	11 11
10	8 45	15 77	73	1 94	10 05	10 60	87	1 30	.....	63 00	.....	7 73
11	44 34	46 57	2 54	3 10	26 65	16 80	1 52	1 12	.....	.....	.....	.....
12	87 89	63 42	7 79	4 49	29 05	31 60	2 57	2 05	330 00	40 00	29 28	2 83
13	33 31	31 76	1 82	2 29	14 80	14 45	81	1 04	.....	.....	.....	.....
14	24 25	39 35	3 31	4 84	5 65	2 80	76	34	.....	.....	.....	.....
15	110 01	68 95	6 08	3 45	43 25	42 55	2 39	2 13	21 00	58 00	1 16	2 91
16	26 21	.....	1 37	.....	7 60	.....	40	.....	.....	.....	.....	.....
17	119 06	31 63	2 29	2 67	37 70	20 30	73	1 72	.....	1,109 25	.....	23 43
18	16 46	20 37	57	72	24 90	27 20	87	95	188 00	.....	6 61	.....
19	39 60	28 04	2 09	1 37	10 75	16 35	56	80	120 00	15 00	6 35	1 73
20	8 48	15 58	1 11	2 28	12 73	7 25	1 66	1 06	40 60	5 00	5 31	73
21	15 68	15 99	79	72	8 59	21 78	43	98	.....	.....	.....	.....
22	32 17	18 54	1 81	1 01	29 53	11 90	1 66	65	.....	5 00	.....	27
23	67 11	.....	2 54	.....	13 30	.....	51	.....	17 00	.....	65	.....
24	7 45	16 88	65	1 41	7 85	16 35	68	1 36	.....	.....	.....	.....
25	14 75	11 51	1 16	98	16 45	6 20	1 30	53	61 00	.....	4 81	.....
26	.....	26 95	.....	1 63	.....	18 60	.....	1 12	.....	544 20	.....	32 82
27	.....	30 14	.....	1 18	.....	16 90	.....	66	.....	32 00	.....	1 25
28	.....	7 68	.....	61	.....	8 30	.....	66	.....	.....	.....	.....
29	.....	105 44	.....	3 34	.....	28 00	.....	89	.....	322 50	.....	10 21
Average....	.....	.....	$1 96	$1 77	.....	.....	$0 86	$0 99	.....	.....	$1 95	$6 25

TABLE IX.—*OTHER EXPENDITURES.*—*Concluded.*

Number of farm.	Added earning power of owner per herd.		Added earning power of owner per cow.		Added risk due to loss of market per herd.		Added risk due to loss of market per cow.		Total expenditures per herd.		Total expenditures per cow.	
	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.
1	$51 78		$6 00		$64 81		$7 51		$1,198 26		$138 82	
2	83 22	$45 18	6 00	$6 00	116 75	$50 70	$8 42	$6 73	2,102 23	$1,307 12	151 53	$160 58
3	55 80	61 08	6 00	6 00	82 02	99 53	8 82	9 78	1,548 56	1,630 03	166 49	160 11
4	58 02	62 28	6 00	6 00	82 02	83 88	8 48	8 08	1,266 91	1,470 13	131 01	141 62
5	184 92	209 55	6 00	6 00	201 22	226 68	6 53	6 52	3,293 42	3,716 99	106 83	106 89
6	154 68	134 10	6 00	6 00	214 62	184 18	8 32	8 25	3,497 43	3,309 50	135 66	148 07
7	89 58		6 00		132 20		8 85		2,766 20		185 28	
8	197 46	184 86	6 00	6 00	240 85	214 64	7 32	6 97	3,942 88	3,732 26	119 78	121 14
9	94 44	89 94	6 00	6 00	159 15	165 01	10 11	11 00	2,734 26	2,866 08	173 71	190 99
10	69 42	48 90	6 00	6 00	83 13	51 43	7 19	6 31	1,666 29	1,222 45	144 03	149 99
11	105 76	90 30	6 00	6 00	173 53	109 17	9 93	7 25	3,064 28	2,329 52	175 50	154 86
12	67 62	84 78	6 00	6 00	114 91	125 06	10 20	8 85	2,582 65	2,387 34	229 55	168 87
13	109 44	83 28	6 00	6 00	193 99	139 52	10 63	10 05	3,320 92	2,466 78	182 07	177 72
14	43 92	48 75	6 00	6 00	55 47	59 52	7 58	7 33	1,202 11	1,278 99	164 22	157 41
15	108 60	119 94	6 00	6 00	174 22	176 12	9 63	8 81	3,126 01	2,902 42	172 68	145 22
16	114 60		6 00		142 44		7 41		2,513 45		131 59	
17	310 80	71 00	6 00	6 00	453 14	125 89	8 74	10 18	8,728 89	3,428 87	168 51	218 95
18	170 64	170 76	6 00	6 00	227 96	220 05	8 02	7 73	4,260 78	4,158 01	149 81	144 82
19	113 34	123 00	6 00	6 00	196 73	185 46	10 41	9 05	3,136 92	2,927 37	166 02	142 81
20	45 84	40 86	6 00	6 00	58 68	50 97	7 68	7 48	1,202 84	905 24	157 42	132 89
21	118 86	133 38	6 00	6 00	172 70	192 80	8 71	8 67	2,826 69	3,181 72	142 67	143 13
22	106 20	110 34	6 00	6 00	167 34	160 64	9 45	8 73	2,700 02	2,408 63	152 53	130 91
23	157 98		6 00		168 15		6 42		3,004 35		114 10	
24	68 82	71 94	6 00	6 00	100 57	103 28	8 77	8 61	1,428 01	1,584 85	124 50	132 17
25	76 02	70 50	6 00	6 00	114 16	110 68	9 01	9 42	1,981 24	1,887 02	156 36	160 60
26		99 48		6 00		195 33		11 78		3,232 16		196 12
27		153 36		6 00		144 38		5 65		2,947 57		115 32
28		75 36		6 00		84 38		6 72		1,424 43		113 40
29		189 48		6 00		298 32		9 45		5,740 53		181 77
Average			$6 00	$6 00			$8 47	$8 30			$150 57	$150 29

Table X contains a summary of the gross receipts for each herd for the two years. Besides giving the total pounds of milk produced, the average production for the herd is shown. Following these columns is the average price of milk per gallon which the farmer received when delivered at the distributing plant or railway dock in Grand Rapids. The reader will keep in mind the fact that the prices actually paid were seasonal. While the practice was not entirely uniform, many of the producers sold for a summer price during four months of the year, and for a winter price during the remaining eight months. The average gallon price, as shown in the table, is obtained by dividing the farmer's entire milk receipts by the number of gallons sold.

The total value of milk produced includes not only that which was sold for the city milk trade, but also all the milk used on the farm or in the farmer's household. As previously stated, all milk used on the farm was charged at the price which it would have netted the producer at his milk house.

Table X also contains the credits for manure produced by each herd. An explanation of these credits has already been given under the heading "Manure" on page 9.

The total herd receipts for each of the two years, and the average receipts per cow, complete the table. At the bottom of the table the general average of each of the items will be found.

TABLE X.—*GROSS RECEIPTS.* AMOUNT OF MILK AND MANURE PRODUCED ON EACH FARM AND THEIR VALUES.

Number of farm.	Pounds of milk per herd.		Average per cent of fat in herd milk.		Number pounds of milk per cow.		Gallons of milk per herd.		Number gallons of milk per cow.		Average price for milk per gallon delivered in the City of Grand Rapids.	
	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.
1	64,757	....	4.46	....	7,504	....	7,802	....	904.0	....	$0 1520	....
2	103,675	50,029	3.60	3.65	7,475	6,910	12,491	6,028	900.6	800.4	1559	$0 1590
3	67,338	101,561	4.11	4.09	7,241	9,976	8,113	9,827	872.4	1,202.0	1700	1700
4	66,566	77,668	4.21	4.03	6,884	7,482	8,020	9,358	829.4	901.5	1717	1506
5	177,205	203,593	3.79	3.94	5,749	5,857	21,350	24,529	692.7	705.7	1578	1559
6	182,218	165,393	3.61	3.72	7,068	7,400	21,954	19,927	851.6	891.6	1649	1572
7	111,564	....	3.89	....	7,473	....	13,442	....	900.4	....	1646	....
8	198,669	192,211	3.93	3.70	6,037	6,238	23,936	23,158	727.3	751.6	1688	1560
9	139,498	147,832	3.47	3.45	8,863	9,855	16,807	17,811	1,069.8	1,187.4	1606	1570
10	71,239	46,482	3.89	3.86	6,158	5,703	8,583	5,600	741.9	687.1	1619	1531
11	142,561	115,958	3.65	3.60	8,165	7,710	17,176	13,971	983.7	928.9	1700	1516
12	96,280	112,337	3.40	3.58	8,543	7,950	11,600	13,535	1,029.3	957.8	1689	1550
13	157,343	123,829	3.54	3.33	8,626	8,921	18,957	14,919	1,039.3	1,074.8	1721	1575
14	45,318	46,960	4.05	4.02	6,327	5,780	5,460	5,658	745.3	696.3	1702	1761
15	138,203	130,196	4.46	4.41	7,636	6,510	16,651	15,686	918.9	784.3	1750	1874
16	117,478	....	4.06	....	6,152	....	14,154	....	741.0	....	1690	....
17	284,329	87,491	4.70	4.87	5,489	7,397	37,871	10,541	731.1	891.1	2000	2000
18	192,485	200,760	3.85	3.85	6,768	7,051	23,191	24,188	815.4	849.4	1649	1559
19	157,891	153,166	3.91	3.81	8,358	7,467	19,023	18,442	1,007.0	899.6	1733	1684
20	48,115	46,016	3.46	3.51	6,298	6,757	5,797	5,544	758.7	814.1	1707	1555
21	151,533	177,579	4.04	4.04	7,648	7,988	18,257	21,395	921.5	962.4	1593	1513
22	137,448	138,757	4.04	4.04	7,765	7,541	16,560	16,718	935.6	908.6	1686	1602
23	146,520	....	3.56	....	5,565	....	17,653	....	670.5	....	1607	....
24	69,820	71,684	4.85	4.68	6,087	5,979	8,412	8,637	733.3	720.3	2000	2000
25	85,042	86,767	3.82	3.75	6,712	7,384	10,246	10,454	807.0	889.6	1868	1770
26	....	161,721	....	3.55	....	9,754	....	19,485	....	1,175.2	....	1683
27	....	143,046	....	3.58	....	5,596	....	17,235	....	674.2	....	1440
28	....	76,376	....	3.99	....	6,081	....	9,202	....	732.6	....	1535
29	....	229,903	....	4.54	....	7,280	....	27,699	....	877.1	....	1800
Average	....	....	3.934	3.944	6,928	7,157	....	....	....	....	$0 1690	$0 1635

TABLE X.—*GROSS RECEIPTS.* AMOUNT OF MILK AND MANURE PRODUCED ON EACH FARM AND THEIR VALUES.—*Concluded.*

Number of farm.	Total value of milk produced per herd.		Value of milk produced per cow.		Credit for manure produced per herd.		Credit for manure produced per cow.		Total receipts per herd.		Receipts per cow.	
	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.
1	$1,180 10	....	$136 74	....	$155 34	....	$18 00	....	$1,335 44	....	$154 74	....
2	1,945 82	$845 54	140 28	$112 28	249 66	$135 54	18 00	$18 00	2,195 48	$981 08	158 21	$130 28
3	1,367 05	1,659 82	146 99	136 04	167 40	183 24	18 00	18 00	1,534 45	1,843 06	164 99	181 04
4	1,367 06	1,397 81	141 45	134 66	160 32	176 46	16 50	17 00	1,527 38	1,574 27	157 95	151 66
5	3,353 63	3,777 95	108 81	108 69	554 76	628 65	18 00	18 00	3,908 39	4,406 60	126 81	126 69
6	3,576 99	3,063 03	138 75	137 05	464 04	402 30	18 00	18 00	4,041 03	3,465 33	156 75	155 05
7	2,203 32	....	147 64	....	269 64	....	18 00	....	2,472 96	....	165 64	....
8	4,014 18	3,577 25	121 97	116 11	543 00	523 77	16 50	17 00	4,557 18	4,101 02	138 47	133 11
9	2,652 48	2,750 24	168 52	183 47	283 32	269 82	18 00	18 00	2,935 80	3,020 06	186 52	201 47
10	1,385 54	857 16	119 75	105 17	208 26	146 70	18 00	18 00	1,593 80	1,003 86	137 75	123 17
11	2,892 09	2,108 29	165 64	140 17	314 28	270 90	18 00	18 00	3,206 37	2,379 19	183 64	158 17
12	1,915 19	2,084 31	169 93	147 50	202 86	254 34	18 00	18 00	2,118 05	2,338 65	187 93	165 50
13	3,233 20	2,325 32	177 26	167 53	328 34	249 84	18 00	18 00	3,561 54	2,575 16	195 26	185 53
14	924 52	992 08	126 30	122 10	120 78	138 13	16 50	17 00	1,045 30	1,130 21	142 80	139 10
15	2,903 67	2,935 39	160 42	146 84	298 65	339 83	16 50	17 00	3,202 32	2,275 22	176 92	163 84
16	2,373 97	....	124 29	....	315 15	....	16 50	....	2,689 12	....	140 89	....
17	7,552 42	2,098 13	145 99	177 36	854 70	195 24	16 50	16 50	8,417 12	2,293 37	162 49	193 86
18	3,799 37	3,667 51	133 60	128 86	511 92	512 28	18 00	18 00	4,311 29	4,179 79	151 60	146 86
19	3,278 85	3,091 06	173 61	150 78	340 02	369 00	18 00	18 00	3,618 86	3,460 06	191 61	171 22
20	978 06	849 50	128 01	124 74	137 52	122 58	18 00	18 00	1,115 58	972 08	146 01	142 74
21	2,878 27	3,213 41	145 29	144 55	326 85	377 91	16 50	17 00	3,205 12	3,591 32	161 79	161 55
22	2,789 02	2,677 33	157 57	145 50	318 60	331 20	18 00	18 00	3,107 62	3,008 53	175 57	163 50
23	2,802 44	....	106 43	....	473 94	....	18 00	....	3,276 39	....	124 43	....
24	1,766 13	1,721 26	146 01	143 55	189 26	197 83	16 50	16 50	1,865 39	1,919 09	162 51	160 05
25	1,902 62	1,844 64	152 00	156 90	228 06	211 50	18 00	18 00	2,130 68	2,056 14	170 00	174 90
26	....	3,255 53	....	196 35	....	298 44	....	18 00	....	3,553 97	....	214 35
27	....	2,406 41	....	94 15	....	447 30	....	17 50	....	2,853 71	....	111 65
28	....	1,406 30	....	111 97	....	219 80	....	17 50	....	1,626 10	....	129 47
29	....	4,971 93	....	157 40	....	536 86	....	17 00	....	5,508 79	....	174 40
Average	....	....	$141 35	$139 01	....	....	$17 45	$17 59	....	....	$158 80	$156 60

Table XI completes the accounts for the several farms and shows the net receipts together with the profit or loss, as the case may be. The third double column headed "Net Profit per Herd," shows that during the year 1914 on eighteen of the twenty-five farms, the dairy enterprise was conducted at a profit, and that during the same year the dairy enterprise was an occasion for loss on the remaining seven farms. Again, in the second year, there are eighteen farms in the profit list and seven that show a loss. Of the seven losing farms four showed a loss during both years, one showed a profit during the first year, and the remaining two were under investigation during the second year only.

TABLE XI.—*NET RECEIPTS.* SHOWING A PROFIT OR LOSS ON EACH FARM AND THE COST OF PRODUCTION PER GALLON AND PER HUNDREDWEIGHT.

Number of farm.	Net cost of production per herd.		Net cost of production per cow.		Net profit per herd.		Net loss per herd.		Net profit per cow.	
	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.
1	$1,042 92	....	$120 85	....	$137 18	....	....	....	$15 89	....
2	1,852 57	$1,171 58	133 56	$155 30	93 25	....	....	$326 04	6 72	....
3	1,381 16	1,446 79	148 49	142 11	....	$213 03	$14 11	....	....	$20 93
4	1,106 59	1,293 67	114 54	124 62	260 47	104 14	....	....	26 94	10 03
5	2,738 66	3,088 34	88 83	88 85	614 79	689 61	....	....	19 98	19 84
6	3,033 39	2,907 20	117 66	130 08	543 60	155 83	....	....	21 09	6 97
7	2,496 56	....	167 28	....	....	....	293 24	....	....	....
8	3,399 88	3,208 49	103 29	104 14	614 30	368 76	....	....	18 67	11 97
9	2,450 94	2,596 26	155 71	173 19	201 54	153 98	....	....	12 81	10 26
10	1,458 03	1,075 75	126 02	131 99	....	....	72 49	218 59	....	....
11	2,750 00	2,058 62	157 50	136 87	142 09	49 67	....	....	8 14	3 30
12	2,379 79	2,133 00	211 55	150 94	....	....	464 50	48 69	....	....
13	2,992 58	2,216 94	164 07	159 72	240 62	108 38	....	....	13 19	7 81
14	1,081 33	1,140 86	147 72	140 41	....	....	156 81	148 78	....	....
15	2,827 36	2,562 59	156 19	128 20	76 31	372 80	....	....	4 24	18 65
16	2,198 30	....	115 09	....	175 67	....	....	....	9 20	....
17	7,874 19	3,233 63	152 01	202 45	....	....	311 77	1,124 60	....	....
18	3,748 86	3,645 73	131 82	128 10	51 51	21 48	....	....	1 80	76
19	2,796 90	2,558 37	148 02	124 80	481 91	532 69	....	....	25 59	25 99
20	1,065 32	782 66	139 44	114 93	....	66 84	87 26	....	....	9 81
21	2,499 84	2,803 81	126 18	126 13	378 43	409 60	....	....	19 12	18 43
22	2,381 42	2,177 43	134 53	112 90	407 60	599 72	....	....	23 03	32 59
23	2,530 41	....	96 10	....	272 04	....	....	....	10 34	....
24	1,238 75	1,387 02	108 00	115 67	437 38	334 24	....	....	38 01	27 87
25	1,753 18	1,675 52	138 36	142 60	149 44	169 12	....	....	11 79	14 30
26	....	2,953 72	....	178 14	....	301 81	....	....	....	18 20
27	....	2,500 27	....	97 82	....	....	....	93 86	....	....
28	....	1,204 63	....	95 91	....	201 67	....	....	....	16 05
29	....	5,203 67	....	164 77	....	....	....	231 74	....	....
Average	....	....	$133 12	$132 70	....	....	....	....	$8 23	$6 31

TABLE XI.—*NET RECEIPTS.* SHOWING A PROFIT OR LOSS ON EACH FARM AND THE COST OF PRODUCTION PER GALLON AND PER HUNDREDWEIGHT.—*Concluded.*

Number of farm.	Net loss per cow.		Net cost of production per gallon.		Net cost of 100 pounds of milk.		Profit per gallon.		Loss per gallon.	
	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.	First year.	Second year.
1			$0 1513		$1 82		$0 0175			
2		$30 30	1480	$0 1944	1 78	$2 34	0074			$0 0541
3	$1 50		1702	1472	2 05	1 77		$0 0217	$0 0017	
4			1380	1382	1 66	1 67	0325	0112		
5			1282	1258	1 54	1 52	0288	0282		
6			1380	1458	1 66	1 76	0248	0079		
7	19 64		1860		2 24				0218	
8			1677	1385	2 02	1 67	0257	0159		
9			1460	1457	1 76	1 76	0119	0086		
10	6 28	26 82	1700	1921	2 05	2 31			0084	0408
11			1600	1472	1 93	1 77	0083	0038		
12	41 62	3 44	2050	1576	2 47	1 90			0400	0036
13			1580	1486	1 90	1 79	0127	0073		
14	21 42	18 31	1980	2016	2 39	2 43			0287	0263
15			1698	1634	2 05	1 97	0046	0237		
16			1553		1 87		0124			
17	6 02	95 06	2080	3057	2 51	3 68			0082	1067
18			1616	1492	1 95	1 80	0022	0024		
19			1470	1387	1 77	1 67	0253	0289		
20	11 41		1839	1412	2 22	1 70		0121	0152	
21			1370	1310	1 65	1 58	0207	0191		
22			1439	1243	1 73	1 50	0246	0359		
23			1430		1 72		0150			
24			1470	1605	1 77	1 93	0520	0386		
25			1710	1602	2 06	1 93	0146	0160		
26				1516		1 83		0155		
27		3 67		1451		1 75				0054
28				1309		1 58		0219		
29		7 34		1879		2 26				0083
Average			$0 1590	$0 1539	$1 916	$1 854	$0 0100	$0 0073		

If one computes the average profit on all the profitable dairies and the average loss on all the unprofitable ones, it would be expressed as follows:

Average yearly profit for 18 dairies	$281.43
Average yearly loss for 7 dairies	256.61

If the number of profitable and unprofitable dairies were expressed in terms of per cent the showing would be as follows:

Number of profitable dairies	72%
Number of unprofitable dairies	28%

Some readers will want to know why these unprofitable dairies were operated at a loss. In other words, they will ask the investigators to diagonse the case and locate the trouble. The following brief notes indicate the major causes.

Dairy No. 2.
Lost in 1915. Main cause was tuberculosis, the loss from this source averaging $25.69 for every cow kept in the herd. The secondary cause for loss was the low price received for the milk product. The gallon selling price each year was less than the general average of all sale prices.

Dairy No. 3.
Lost in 1914. The dry summer of 1913 caused a marked shortage of dairy feeding crops. This farm being one of those where a considerable amount of summer feeding was necessarily practiced, the more expensive winter feeding of 1913-14 was not relieved by resourceful and cheap pastures in the summer of 1914, consequently the sustained supplementtary feeding absorbed the possible profits and entered the field of real loss.

Dairy No. 7.
Lost in 1914. The feeding conditions on this farm were quite similar to those of Dairy No. 3, mentioned above. More expensive cartage of feeds and hauling of milk are responsible for additional losses. The milk hauling alone exceeded the average cost by $8.75 per cow.

Dairy No. 10.
Lost in 1914 and also in 1915. The loss during 1914 cannot be attributed to any particular cause or class of causes. The loss for 1915 may be explained by a rather low production. A portion of this low production was directly chargeable to several cases of udder trouble, some farrow cows, and one death.

Dairy No. 12.
Lost in 1914 and also in 1915. The main reason for the losses on this farm was the large number of animals condemned on account of tuberculosis during the year 1914. The lower selling price for the second year, grade of milk being duly considered, was the leading cause of loss.

Dairy No. 14.
Lost in 1914 and also in 1915. This farm was not equipped with a silo. The production was consequently lower and the feeds relatively

more expensive. A secondary cause of loss was the higher cost of housing. The buildings were really very superior, as has been shown by the inventory.

Dairy No. 17.

Lost in 1914 and also in 1915. The loss of the first year can be traced to no special cause as a fault in production, unless it might be that of too liberal feeding.

The reader will note that the wholesale price of the milk was 20c per gallon. It is very doubtful if milk of the grade and quality of that produced on this farm could be profitably put upon the wholesale market at that price.

During the second year still further losses were occasioned by a large number of reacting animals.

Dairy No. 20.

Lost in 1914. With the very narrow margins of profit at which dairy production is conducted, it is inevitable that some will lose. This herd had a reasonable production and its general conduct was not such as to deserve a loss.

Dairy No. 27.

Lost in 1915. In this herd the production was low. Feed and labor, however, were commensurately inexpensive. The items showing the greatest occasion for loss were hauling milk and other horse labor, which amounted to 3.9c per gallon.

Dairy No. 29.

Lost in 1915. The market for the grade of milk produced in this dairy was not sufficiently extensive to take care of the business enterprise as conducted. The necessity of maintaining a constant milk flow, and the attendant added feeding charges, coupled with death losses, were among the secondary causes for an unprofitable year.

In reviewing the above notes, a reader might possibly assume that the dairies showing the greatest losses on account of compulsory tuberculin test were those just beginning to put their product on the city market. This was not true, because the greatest share of such losses actually did occur in those herds in which city milk production had been continuously carried on for a number of years under city inspection with compulsory annual tests by the city authorities.

The question that will arise in many readers' minds is: Under what conditions are profits or losses brought about?

No one factor seems to determine a profit or loss. In some cases high producing herds have failed to be remunerative; while in others very low producing herds have made a profit. The cost of labor, feeds, the investment, as well as the system of management of the business, are important factors. Losses due to tuberculosis played a very important part in raising the cost of milk, and since these losses are occasioned by, and sustained wholly in compliance with city ordinance, it is eminently fair and equitable that the producer should receive sufficient compensation for his improved product to safeguard him against losses from this source.

Buildings poorly arranged, hauling feed and milk in small quantities for long distances and the, maintaining of low producing cows, tend to raise the cost of production.

Moderate investment in buildings and equipment, systematized labor, moderate priced feeds, and high producing cows, are inducive to profits. On the other hand, the price received for the product determines a profit or loss when milk is produced under economical conditions. The price secured should be great enough to allow a fair margin of profit.

The graphic charts which follow present a summation of the receipts and expenditures of each of the dairies under investigation for each year.

The farm number appears at the bottom of the chart, and above each of these numbers are two upright columns. The one at the left is divided into three separate parts; the one at the right into two parts. From the explanatory material at the bottom of the chart one will understand that the aggregate of the three portions of the left-hand column shows the average costs per cow of that dairy, and the aggregate of the two portions of the right-hand column shows the average receipts per cow of that farm's dairy. The reader will therefore understand that in each case where the left-hand column is higher than the right-hand column the total expenses are greater than the total receipts and a loss is indicated. When the right-hand column is higher than the left-hand one, the receipts are greater than the expenditures, and a profit is indicated.

The last double column at the right of the diagram is labeled "Av.," and shows the average of all the dairies on the chart.

For the convenience of the reader the average figures for each of the three classes of expenditures and each of the two classes of receipts, appear at the extreme right of the chart.

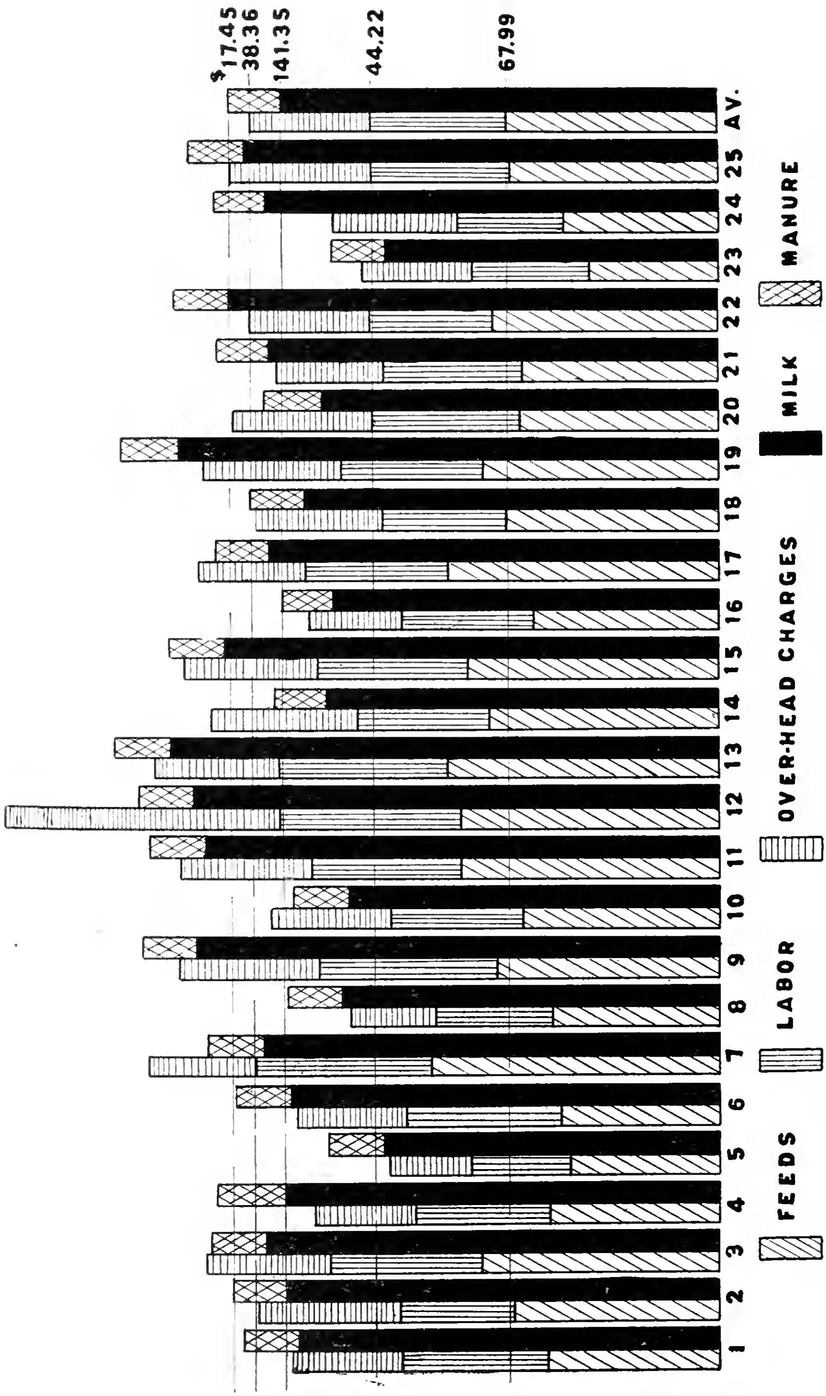


Plate I. Graphic chart showing the expenditures and receipts per cow on each of the twenty-five dairy farms for the year 1914.

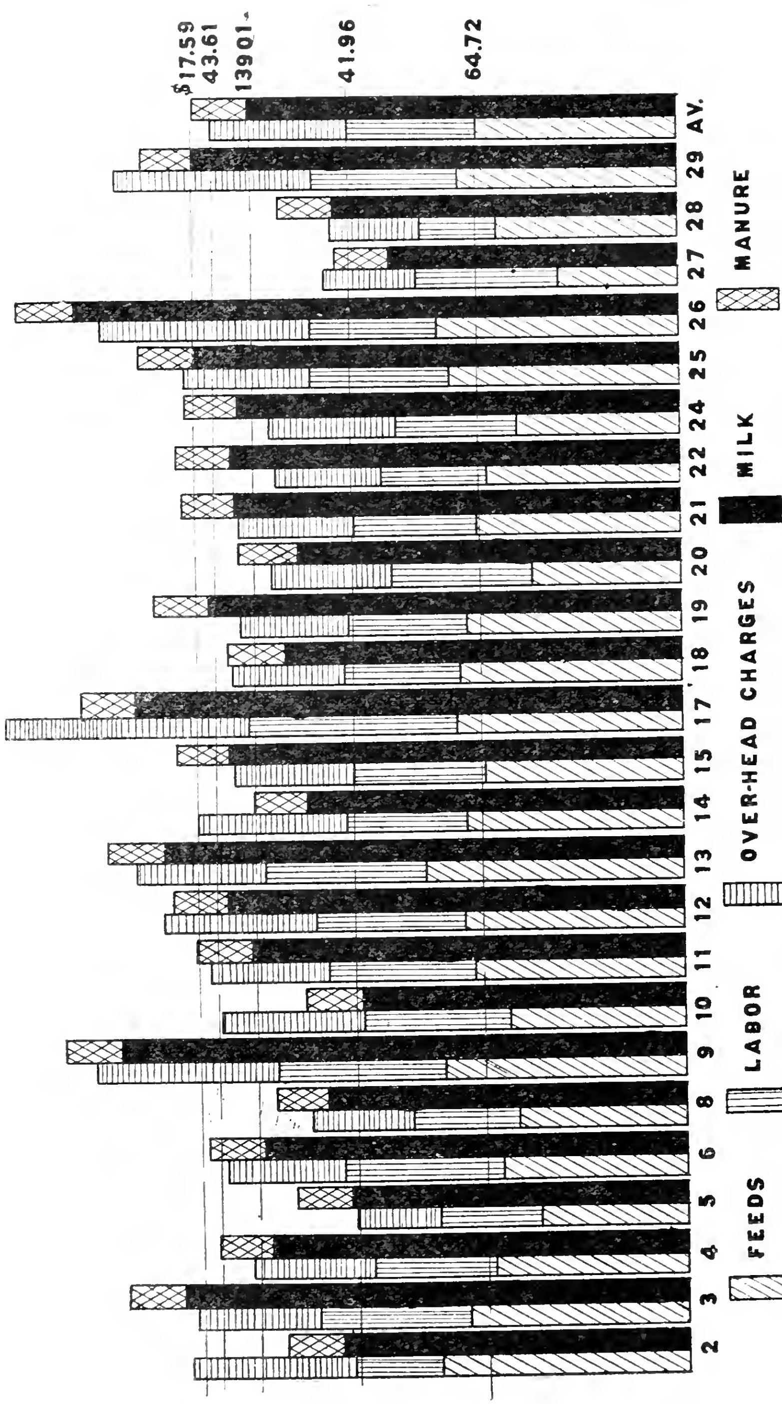


Plate 11. Graphic chart showing the expenditures and receipts per cow on each of the twenty-five dairy farms for the year 1915.

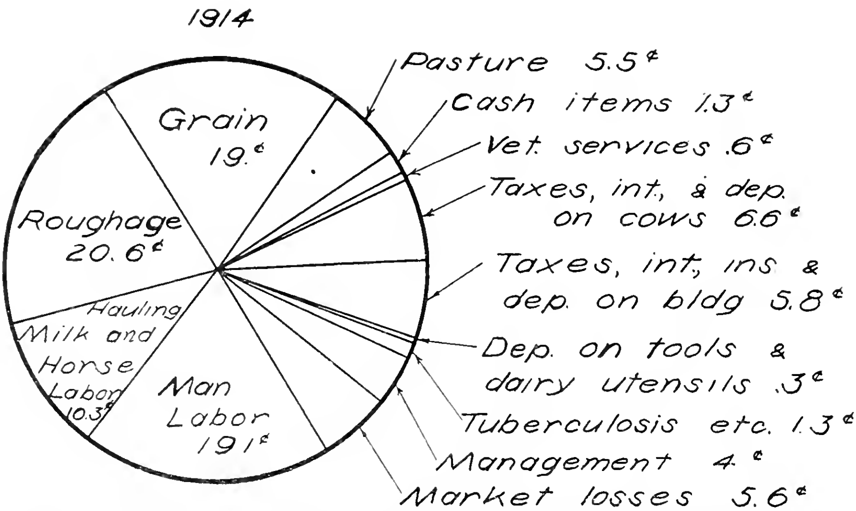


Plate III. The above diagram shows the distribution of the average dollar expended for milk production in 1914, all the dairies under investigation being considered.

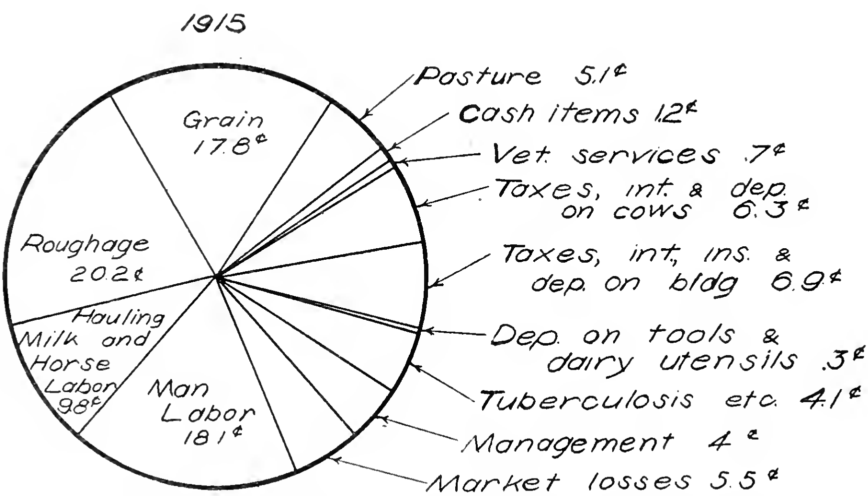


Plate IV. The above diagram shows the distribution of the average dollar expended for milk production in 1915, all the dairies under investigation being considered.

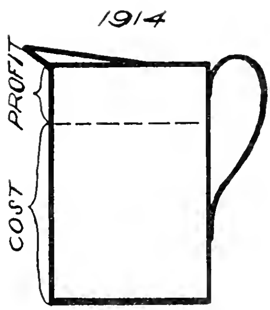


Diagram showing relative proportions of cost & profit for one gallon of milk in most profitable dairy

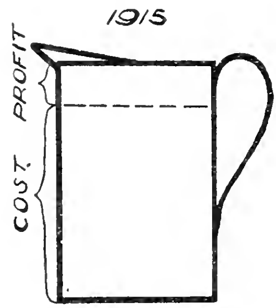


Diagram showing relative proportions of cost & profit for one gallon of milk in most profitable dairy

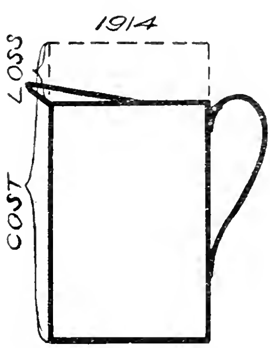


Diagram showing relative proportions of cost and loss for one gallon of milk in most unprofitable dairy

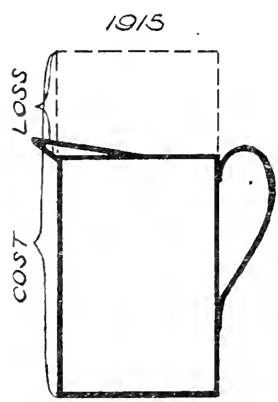


Diagram showing relative proportions of cost and loss for one gallon of milk in most unprofitable dairy

Plate V.

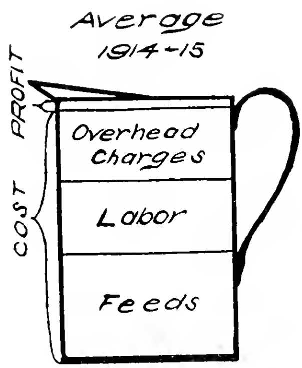


Diagram showing the relative proportions of the three classes of costs & the profit in the average gallon of milk which represents the entire output of all the farms for the two years.

Plate VI.

LAST WORD.

The reader will realize that cost accounting, especially in its pioneer stages, of necessity is historical in its nature. Consequently data extending over a considerable portion of time are always liable to be somewhat out of date when completed. The figures as set forth in this bulletin will need some adaptation to make them applicable to present price conditions.

During the last two years the cost of labor has increased about 25%, of concentrated feeds 30%-35%, of Roughage 10%, and of the minor supplies and milk room equipments 25%-50%.

By using the feed and labor values that prevail in his vicinity the producer will be able to adapt the several cost items to his locality and his own conditions.

FERTILIZER ANALYSES

Bulletin No. 278.

ANDREW J. PATTEN, E. F. BERGER, A. E. SMOLL AND E. A. DEWINDT.

The inspection and analyses of commercial fertilizers offered for sale in Michigan are made under authority of an act of the Legislature approved March 10th, 1885, and as amended during the session of the Legislature for the year 1913. The principal points in the law of interest to manufacturer, dealer and consumer may be summarized as follows:

MANUFACTURER.

Materials subject to license. The term "commercial fertilizer" shall be held to include any and every substance, imported, manufactured, prepared or sold for fertilizing or manurial purposes, the retail price of which is ten dollars or more per ton. (Sec. 1.)

Statement of analysis. Before any commercial fertilizer can be legally sold or offered for sale in the State the net weight of the package, the name of the brand and name and address of the manufacturer must be printed on the bag or on a card attached to the bag together with the guaranteed analysis in the following form:

Nitrogen .... %
Available Phosphoric Acid .... %
Total Phosphoric Acid .... %
Potash (K_2O) .... %

No other form stating the guarantee is permissible. The attention of manufacturers who use the sliding guarantees and the equivalent guarantees is particularly called to the above form of stating the guaranteed analysis. (Sec. 1.)

Registration. Before any commercial fertilizer is sold or offered for sale, the party selling or offering the same for sale shall file with the Chemist of the Experiment Station a certified copy of the analysis and also a sealed glass jar containing not less than two pounds of such fertilizer, with an affidavit that it is a fair sample of the article to be sold or offered for sale. Registration blanks for this purpose will be furnished on application. Registrations must be made on all brands each year but samples are required only at the time of the first registration. It is the ruling of this Department that any change in the brand name or in the guarantee constitutes a new brand. (Sec. 2.)

License fee. A license fee of twenty dollars for each brand of fertilizer sold or offered for sale should be paid on or before May 1st of each year or before the fertilizer is offered for sale in the State. All checks

covering license fees should be made payable to the Secretary, State Board of Agriculture. (Sec. 3.)

Penalties. Any person or persons who shall be found guilty of selling or offering for sale any commercial fertilizer in violation of the provisions of the law shall be fined not less than one hundred dollars for the first offense and not less than three hundred dollars for each subsequent offense. (Sec. 6.)

DEALERS.

Companies to represent. Represent only such companies as properly register all the brands they send into the State. Before accepting a shipment of fertilizers for resale find out by writing to the Chemist of the Experiment Station if the registration has been made and the license fee paid.

Storing. Fertilizers should be stored in a dry, waterproof building and should never be piled directly on the ground. Failure to observe this precaution may cause the fertilizers to absorb an unusual amount of moisture and, consequently, to run below guarantee. Furthermore, improperly stored fertilizer is liable to become hard, in which condition it cannot be handled in a drill without regrinding and even distribution by hand is much more difficult. When two or more brands of fertilizer are stored in the same building they should be separated by a narrow aisle to insure against the brands getting mixed.

Sampling. Any duly authorized agent of the State Board of Agriculture is empowered to select samples, for the purpose of analysis, from any commercial fertilizer exposed for sale in the State. All inspectors sent out for this purpose will be provided with an authorization signed by the Secretary of the State Board of Agriculture and only such persons have authority to collect samples.

CONSUMERS.

The fertilizer law is for your protection, therefore do not purchase unlicensed fertilizers from dealers outside of the State, even when offered at a great bargain, for, in such cases, the law can offer you no protection.

Do not send samples for analysis without first writing to the Chemist of the Experiment Station for instruction in regard to taking the sample. This is very important as this Department will analyze only those samples secured by the regular inspectors or those taken in accordance with our instructions.

Consult the fertilizer bulletins and find out what companies are most consistently fulfilling their obligations as to the amounts of plant-food guaranteed.

Low crop yields may be due to any one of a number of causes such as poor drainage, soil acidity, poor physical condition, insufficient moisture, unfavorable climatic condition, lack of available plant-food, etc. Fertilizers can correct only one of these causes, namely, lack of plant-food, and they should not be condemned when they fail to produce results if the real cause of low yields is due to some other condition.

The best results from the use of commercial fertilizers will be obtained, only, when all of the conditions affecting plant growth are as nearly

perfect as it is possible to make them. "Fertilizers are foods (not stimulants) for healthy soils. They are not medicine for sick land."

Study your soil conditions and by experimenting determine what forms of plant-food, if any, are required and in what amounts they should be used to produce the most economical results. Only in this way can these questions be definitely answered.

LICENSED BRANDS.

Thirty-six manufacturers and fertilizer companies have licensed 301 distinct brands for sale in the State during the season of 1916. The brands appearing in the following tables of analyses, and none others, can be legally sold.

Parties mixing or importing fertilizers for their own use and not for sale are not affected by the restrictions of the law and neither are they protected under it.

COLLECTION OF SAMPLES.

The collection of samples was made during the spring and fall shipping seasons by inspectors appointed by the State Board of Agriculture. All sections of the State in which fertilizers are used to any extent were covered and 600 samples secured from stocks being offered for sale by dealers. For this purpose a specially constructed tube is used which permits of securing a core from the entire length of the bag. In no case is a sample drawn from less than five bags nor from bags that have previously been opened. The samples are drawn and sealed in the presence of a witness and shipped to the laboratory for analysis.

As much of the fertilizer used in the State is taken directly from the cars by the consumer, it is never possible for the inspectors to secure samples of all the brands registered. In such cases the samples submitted by the manufacturers at the time of applying for the licenses are analyzed. These samples may be distinguished from the officially collected samples by the omission of the letter "A" preceding the laboratory number. No analyses are reported for eleven brands as no shipments were found by the inspectors and no samples were submitted by the manufacturers.

RESULTS OF INSPECTION.

(a) Quantity of plant-food.

A study of the tables of analyses shows that, of the 549 samples analyzed, representing 290 brands, 92 (16.8%) are below guarantee* in one or more constituent. Thirty (5.5%) are below guarantee in nitrogen, 38 (6.9%) are below in available phosphoric acid, 6 (1.0%) in total phosphoric acid and 23 (4.2%) in potash.

*A shortage of more than 0.10 per cent of nitrogen or more than 0.20 per cent available phosphoric acid or potash is considered below guarantee.

SUMMARY OF RESULTS OF INSPECTION.

Manufacturer.	Number of brands licensed.	Number of samples analyzed.	Number below guarantee in one or more ingredient.	Number equal in value to guarantee.	Number not within 5 per cent of value guaranteed.	Number not within 10 per cent of value guaranteed.	Number 5 per cent or more above value of guarantee.
American Agricultural Chemical Co.	78	155	4	154	0	0	152
Ann Arbor Abattoir Co.	1	1	1	0	0	0	0
Armour Fertilizer Works	19	54	9	54	2	0	41
R. Binder	1	1	0	1	0	0	1
James Boland Rend. & Fert. Co.	1	1	1	1	0	0	1
E. Burton	1	1	1	1	0	0	0
Chicago Feed & Fertilizer Co.	4	4	3	2	2	0	2
Chicago Raw Products Co.	2	3	1	3	0	0	3
Darling & Company	10	28	4	27	0	0	24
Farmers Fertilizer Co.	8	18	3	18	0	0	16
Grand Rapids Glue Co.	1	1	1	1	0	0	1
Grange Fertilizer Co.	7	9	0	9	0	0	8
Hirsh Stein & Co.	9	15	7	13	0	0	11
Independent Packers Fert. Co.	8	10	4	6	1	0	6
International Agricultural Corporation	12	17	2	15	0	0	11
Jarecki Chemical Co.	12	27	6	24	0	0	14
Kalamazoo Rendering & Fertilizer Co.	2	2	1	2	0	0	2
Mineral Fertilizer Co.	1	7	4	3	3	3	3
Natural Guano Co.	1	1	0	1	0	0	1
Nitrate Agencies Co.	2	0	0	0	0	0	10
The Packers Fertilizer Co.	10	16	3	15	0	0	10
Pulverized Manure Co.	2	3	0	3	0	0	3
Queen City Fertilizer Co.	1	1	0	1	0	0	1
Rasin Monumental Co.	17	20	1	23	0	0	17
F. S. Royster Guano Co.	17	24	5	23	0	0	19
Smith Agricultural Chemical Co.	10	20	1	19	0	0	16
Speidel & Swartz	1	1	1	1	0	0	1
J. L. & H. Stadler Rendering & Fert. Co.	13	18	3	18	0	0	14
G. B. Stock Xylite Grease & Oil Co.	1	0	0	0	0	0	0
Swift & Company	32	70	24	64	2	0	29
Tuscarora Fertilizer Co.	5	5	0	5	0	0	2
Virginia-Carolina Chemical Co.	6	5	1	4	0	0	4
The Wuichet Fertilizer Co.	6	11	1	11	0	0	11
Totals	301	549	92	522	10	3	424

In reviewing the foregoing summary we find 94.7 per cent of the samples analyzed containing amounts of plant-food equal in value to that guaranteed and 77.2 per cent of the samples containing amounts of plant-food 5 per cent or more in excess of that guaranteed. Only 1.8 per cent of the samples analyzed show a deficiency of 5 per cent in the value of the plant-food guaranteed. Three samples, all from one company, show a deficiency of 10 per cent in the value of the plant-food guaranteed.

These facts indicate that the manufacturers, as a whole, are endeavoring to fulfill their guarantees as to the amount and value of the plant-food supplied in the fertilizers sold in Michigan.

QUALITY OF PLANT FOOD.

It is again necessary to call attention to the quality of the nitrogen supplied in many of the fertilizers and to urge a careful study of the tables which follow, in order to determine what brands furnish the larger part of the nitrogen in those forms which are recognized as being more or less readily available. In interpreting these results, the follow-

ing points should be remembered: That water-soluble nitrogen is readily available for plant uses, and that the water-insoluble nitrogen ("active insoluble" and "inactive insoluble") may or may not be readily available for plant uses.

When the amount of "active insoluble" nitrogen is greater than the amount of "inactive insoluble" nitrogen, the total water-insoluble nitrogen is considered to be readily available to plants; when the amount of "active insoluble" nitrogen is less than the "inactive insoluble" nitrogen the total water-insoluble nitrogen is not considered to be readily available and the plants may fail to derive any benefit from its use.

Many of the fertilizer brands reported in this bulletin, especially those having small percentages of nitrogen, show a large proportion of the nitrogen to be in water-insoluble forms of questionable quality.

CONCERNING PRICES.

Owing to the continued demand from other sources, for many of the materials used in the fertilizer industry, there is no hope for a reduction in the prices for the coming season.

Nitrate of soda has advanced about $20.00 per ton and this has caused a stiffening in the price of practically all ammoniates. Acid phosphate will be from three to five dollars per ton higher than the average price two years ago and potash will undoubtedly cost the purchaser not less than $5.00 per unit in mixed fertilizers.

No domestic sources of potash of any consequence have been found in this country to replace that which formerly was imported from Germany.

Under these conditions it behooves every person who contemplates the use of commercial fertilizers next spring, to consider well the needs of his soil and to purchase that brand or formula that will supply the needed elements at the least cost, keeping in mind the availability of the nitrogen, whenever this element is purchased.

NU-LIFE FERTILIZER.

Attention is called to this fertilizer which was offered for sale in the State during the past season by the Mineral Fertilizer Company, Chicago, Illinois. It was guaranteed to contain 15 per cent phosphoric acid. No claim was made for available phosphoric acid although in a letter addressed to the senior author under date of December 11, 1915, the material was stated to be basic slag. In the advertising circulars sent out, the following statements were found:

"The basis of Nu-Life Fertilizer is Slag Meal."

"Nu-Life Fertilizer is slag meal and additional available phosphoric acid."

An investigation as to the nature of this material proved it to be a mixture consisting of about equal parts of raw rock phosphate and slag from an open hearth iron furnace. As this open hearth slag contains less than 4 per cent of phosphoric acid, it is at once evident that, at least, 85 per cent of the phosphoric acid in *Nu-Life* Fertilizer is derived from raw rock phosphate and its commercial or agricultural value should be no greater than that of rock phosphate of the same grade. Rock phos-

phate containing 30 per cent phosphoric acid can be purchased for about $10.00 per ton f. o. b. any point in lower Michigan.

Samples were drawn from stock in the hands of the following list of dealers:

Addison—John Landon.
Adrian—Cutler Dickerson Co., J. C. Van Doren, J. L. Dibble, J. E. Bubgee, Frank Walworth.
Alto—Dentaman Bros.
Ann Arbor—Ann Arbor Abattoir Co., Hertler Bros.
Auburn—J. P. Schuster.
Azalia—Fred Jasper.
Bannister—Bannister Elevator Co.
Batavia—Batavia Co-operative Assn.
Battle Creek—Robert Binder Estate, Powers & Co.
Bay City—Bechlin Hardware Co.
Beech—Geo. W. Burt, Geo. Wright, Geo. Fisher, Sylvester Shear.
Belleville—Van Schoick Bros., Albert Richardson, H. W. Dunham, Geo. Freeman.
Benton Harbor—Cutler Downing & Co., B. M. Nowlin & Co.
Berlin—Blink Bros.
Blissfield—E. J. Gray, Continental Sugar Co.
Bradley—H. F. Buskirk.
Bridgman—Bridgman Supply Co.
Britton—Lowe & Palmer, Geo. R. Carter.
Buchanan—Chas. F. Boyle.
Byron Center—J. Burmania.
Carlton—C. A. Vandercook, H. C. Reiser.
Caro—Caro Elevator Co.
Carson City—O. W. Gage.
Charlotte—McUmber & Tirrill.
Cass City—Striffler & Patterson, J. A. Cole.
Chesaning—Schwartzmiller & Stuart, Chesaning Hardware Co.
Coatsgrove—John Blocher.
Coldwater—Coldwater Co-operative Assn.
Coloma—Reuben Hazen, Coloma Hardware Co.
Columbus—Jos. Fogarty.
Conklin—M. D. Bunker, Stockhill & Emmons.
Coopersville—M. Durham, R. Reynolds, Laug Bros., F. S. Hambleton, Chas. Taylor.
Coral—Chapel & Skeoch.
Davison—O. K. Hathaway.
Dearborn—S. D. Lapham.
Devereaux—E. E. Stokoe.
Deckerville—J. P. Greenan.
Deerfield—Chas. Helzer, Frank Timmons, F. W. Cannon.
Derby—C. P. Smith & Sons.
Dexter—Henry Kleinschmidt.
Dundee—Dundee Mercantile Co., Michigan Milling Co., Irving Moore, Harry Watson.
Durand—Alfred Vincent.
East Saugatuck—John Lubbers & Sons.

Elba—Elba Elevator Co.
Elm—Bentley Bros., Ira Wilson.
Elsie—Hankins Bros., B. M. Wooley.
Erie—Chas. Choate.
Essexville—Adrian Van West.
Fennville—W. E. Collins, F. J. Wattles.
Fenton—J. A. Thompson.
Flat Rock—John Chamberlain, Bryant Bros., McIntyre & Crooks.
Flint—J. P. Burroughs & Son.
Fowler—G. F. Stowe.
French Landing—J. F. Riggs.
Fremont—Fremont Co-operative Assn.
Flushing—J. P. Frawley Bros.
Galien—Swank Bros.
Grand Haven—Speidel & Swartz, Peter Van Zylen.
Grand Junction—L. F. Davis.
Grand Ledge—A. H. Munn.
Grand Rapids—Reed & Cheney, Brown Seed Co., Elaborated Roofing Co., E. J. Maskum.
Hartford—High & Thompson.
Haslett—Wilmer Coleman.
Hastings—Edmonds Bros.
Harlem—Peter Braamse.
Hillsdale—William Cole, G. A. Aldrich & Co., William Kelley.
Holland—G. Cooke & Co., H. P. Zwemer.
Hollaway—F. J. Blouch.
Holly—W. H. Meacham.
Hudson—Atherton & Coppins.
Hudsonville—Jacob Keel, C. Spoelman.
Ida—Geo. Schuler, Geo. Schafer, Ida Hardware Co., N. A. Weipert & Sons, J. E. Snell.
Imlay City—D. F. Jurn.
Inkster—F. Fisher.
Ithaca—Gleaner Farmers Elevator Co.
Jackson—Jas. Boland Rendering & Fertilizer Co.
Jonesville—A. H. Dudley.
Kalamazoo—Kalamazoo Rendering & Fertilizer Co.
Kawkawlin—Stevig Hardware Store.
Kent City—Victor Broman, Kent City Produce Co.
Lansing—Dubois & Hughes, H. E. Saier.
La Salle—Arthur Neidermeier, C. L. Miller.
Lawton—Chas. G. Hall.
Lenawee Junction—Geo. Bueherer.
Lowell—H. Nash.
Lulu—C. Vandercook.
Manchester—M. A. Lemm, J. W. Schlicht, Schud & Houck.
Marine City—Zimmerman Bros.
Mason—Mason Elevator Co.
Maybee—F. W. Schmidt, Will Thoma, C. & G. Hochradel.
Milan—Fred Bachman, Jas. Hack, John Murray, McCrone Bros., Forsythe & Lee, Auten Camburn Grain Co., J. Talliday.
Millington—Sioux City Seed Co., Roy A. Haines.
Monroe—Fisher & Neil, Fred Kingsting.

Montgomery—Tri-state Co-operative Assn., Harley Adams.
Morenci—Chas. Fay, Frank Sanborne.
Mulliken—Noble Implement Co.
Munson—G. E. Lehmen.
Muskegon—Stegink & Son, J. Marvin, J. E. Martin.
New Boston—E. Gumtow, Fred Knope, Jas. Vogt, R. E. Krause, Meisner & Dugan, Will Eldred.
Niles—J. S. Tuttle.
North Adams—C. H. Williams.
Northville—Richard Gibson, U. A. Tibbets, A. Ebersole, W. H. Catermole.
North Star—North Star Elevator Co.
Novi—Jas. Erwin.
Nunica—J. D. Pickett, R. S. Brown, Peterson & Easterley.
Ortonville—A. P. Button.
Osseo—F. W. Densmore.
Otsego—G. H. Seple & Co.
Ovid—Thomas Hislop.
Owosso—W. E. Payne.
Perry—Perry Milling Co.
Pittsford—Ray Lockwood.
Petersburg—Nusenmann & Wittman, T. J. Carman, Fred Kohler, E. Thompson, John Heller, C. J. Cilley.
Plainwell—E. H. Ingraham.
Plymouth—H. C. Hager, A. B. Schroder, A. J. Lapham, Art Eckles.
Portland—Portland Farmers' Elevator.
Quincy—Burch & Day.
Ravenna—A. E. Young.
Reading—W. M. Cahow, E. Davis, Byron Field, Arthur Lane, Reading Co-operative Commerce Co.
Richmond—Farmers' Elevator Co., Ira Lovejoy.
Ridgeway—J. J. Harrington.
Rochester—Robert Castel, L. L. Whims.
Romeo—Bradley & Chubb.
Romulus—Elmer Pullen.
Royal Oak—Royal Oak Ice & Produce Co.
Ruth—Frank Cook, J. F. Schroeder.
Saginaw—Wolcott Grain Co., M. A. Dailey.
Saline—Walter Armbruster.
Salzburg—G. L. Frank.
Samaria—S. L. Smith.
Sawyer—W. J. Zeiger, W. P. Glavin.
South Haven—South Haven Fruit Exchange.
Sparta—D. J. Johnson, C. J. Rice, A. S. Bollusis.
St. Clair—John Mau, Chris. Ahler.
St. Johns—John Hicks.
St. Louis—St. Louis Hardware Co.
St. Joseph—Edward Burton.
Stark—T. V. Kerbyson.
Stevensville—E. P. Cupp.
Sunfield—P. J. Griffin.
Tecumseh—Temple & Co., Tecumseh Co-operative Assn.

Traverse City—Traverse City Milling Co.
Three Rivers—Corlett Stone & Lumber Co.
Trenton—H. L. Wagar.
Tyre—S. W. Soule.
Urania—Sherman Cook.
Vandalia—Corlett Stone & Lumber Co.
Vassar—Farmers' Elevator Co., Geo. A. Proctor, Reliance Milling Co., L. D. Haines.
Vriesland—G. W. Hungerink.
Waltz—B. D. Felt, Gus. Elwert, Robert Waltz, Will Neumann.
Wayland—C. A. Ryno.
Wayne—E. H. Langworthy, Wortz & Co., H. F. Hubbard, B. R. Hammond, Ben Simons.
Washington—J. W. Switzer, C. W. Burrough, Luchtman & Payne.
Willis—Bert Roberts, Geo. H. Thompson, J. H. Lord.
Willow—H. C. Otter, G. R. Gifford.
Whittaker—G. W. Kinnicutt & Son.
Zeeland—Isaac VanDyke, C. C. Zeerip.

ANALYSES OF COMMERCIAL FERTILIZERS, FOR 1916, EXPRESSED IN PARTS IN ONE HUNDRED.

Laboratory number.	Manufacturer and Trade Name.	Nitrogen.					Phosphoric Acid.				Potash.	
		As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total found.	*Total guaranteed.*	Total found.	Insoluble.	Available found.	*Available guaranteed.*	Total found.	*Total guaranteed.*
	American Agricultural Chemical Company, Detroit, Mich.											
A 233	Amo Phos Fertilizer	0.76	0.62	0.27	1.65	*1.65*	15.40	2.76	12.64	*12.00*	....	....
A 333	Amo Phos Fertilizer	0.42	0.90	0.42	1.74	*1.65*	15.70	3.08	12.62	*12.00*	....	....
A 389	Amo Phos Fertilizer	0.97	0.56	0.21	1.74	*1.65*	15.50	1.46	14.04	*12.00*	....	....
A 501	Amo Phos Fertilizer	0.67	0.78	0.26	1.71	*1.65*	15.65	2.56	13.09	*12.00*	....	....
A 968	Beet Fertilizer 1916	0.45	0.15	0.30	0.90	*0.82*	12.65	1.98	10.67	*9.00*	1.02	*1.00*
A 906	Crown Phosphate and Potash	....	....	....	....	....	16.25	2.88	13.37	*12.00*	0.96	*1.00*
A 402	Fine Ground Bone	0.59	1.79	0.27	2.65	*2.47*	22.80	....	....	**20.00*	....	....
A 546	Fine Ground Bone	0.58	1.69	0.74	3.01	*2.47*	25.20	....	....	**20.00*	....	....
A 540	Michigan Bean Grower 1916	0.89	0.55	0.46	1.90	*1.65*	11.05	3.02	8.03	*8.00*	1.30	*1.00*
A 549	Michigan Bean Grower 1916	0.85	0.57	0.39	1.81	*1.65*	11.08	3.12	7.96	*8.00*	1.19	*1.00*
A 248	New York State Special 1916	0.41	0.32	0.17	0.90	*0.82*	12.20	1.26	10.94	*8.00*	1.00	*1.00*
A 278	New York State Special 1916	0.49	0.33	0.16	0.98	*0.82*	11.80	1.46	10.34	*8.00*	0.96	*1.00*
A 329	New York State Special 1916	0.55	0.22	0.23	1.00	*0.82*	10.70	2.44	8.26	*8.00*	0.89	*1.00*
A 467	New York State Special 1916	0.49	0.29	0.15	0.93	*0.82*	11.80	1.10	10.70	*8.00*	0.87	*1.00*
10162	Nitrate of Soda	....	....	....	15.60	*15.00*	....	....	....	....	....	....
A 228	1 and 10 Compound	0.38	0.38	0.16	0.92	*0.82*	12.20	2.48	9.80	*10.00*	....	....
A 277	1 and 10 Compound	0.35	0.35	0.14	0.84	*0.82*	12.75	2.72	10.03	*10.00*	....	....
A 841	1 and 10 Compound	0.64	0.22	0.25	1.11	*0.82*	12.75	1.18	11.57	*10.00*	....	....
A 844	1 and 10 Compound	0.42	0.39	0.14	0.95	0.82	13.60	2.02	11.58	*10.00*	....	....
	Bradley Brands.											
10163	Acid Phosphate	....	....	....	....	....	18.90	2.04	16.86	*10.00*	....	....
A 229	16% Acid Phosphate	....	....	....	....	....	18.95	0.98	17.97	*16.00*	....	....
A 882	16% Acid Phosphate	....	....	....	....	....	18.85	0.62	18.23	*16.00*	....	....
A 820	All Crops Fertilizer	0.36	0.33	0.14	0.83	*0.82*	12.20	1.24	10.96	*10.00*	1.04	*1.00*
A 272	B. D. Sea Fowl Guano No. 1	1.19	0.67	0.38	2.24	*2.06*	12.45	4.40	8.05	*8.00*	1.20	*1.00*
A 271	B. D. Sea Fowl Guano No. 2	1.28	0.65	0.34	2.27	*2.06*	11.23	4.17	7.06	*8.00*	....	....

A	401	B. D. Sea Fowl Guano No. 2	1.13	0.75	0.47	2.35	*2.06*	11.05	3.02	8.03	*8.00*		
A	502	B. D. Sea Fowl Guano No. 2	1.26	0.76	0.40	2.43	*2.06*	12.10	3.42	8.68	*8.00*		
A	227	Dissolved Bone Phosphate with Potash 1916	0.46	0.32	0.21	0.99	*0.82*	11.50	1.70	9.80	*8.00*	1.18	*1.00*
A	503	High Phos Formula						21.10	2.10	19.00	*18.00*		
A	922	High Phos Formula						23.90	3.96	19.94	*18.00*		
A	881	Niagara Phosphate	0.35	0.27	0.19	0.81	*0.82*	10.15	1.40	8.75	*7.00*	1.20	*1.00*
A	328	Soluble Dissolved Bone Phosphate						17 15	1 70	15 45	*14.00*		
A	921	Soluble Dissolved Bone Phosphate						17.75	1.78	15.97	*14.00*		
A	327	Special Potash Fertilizer 1916	0.57	0.28	0.12	0.97	*0.82*	11.85	2.34	9.51	*8.00*	1.00	*1.00*
A	403	Special Potash Fertilizer 1916	0.63	0.22	0.10	0.95	*0.82*	11.95	2.14	9.81	*8.00*	1.05	*1.00*
		Crocker's Brands.											
A	253	10% Acid Phosphate						12.23	1.26	10.97	*10.00*		
A	880	10% Acid Phosphate						11.60	1.00	10.60	*10.00*		
A	255	Ammoniated Wheat and Corn Phosphate 1916	0.95	0.69	0.40	2.04	*2.06*	11.55	3.54	8.01	*8.00*	1.00	*1.00*
A	247	Ammoniated Wheat and Corn Phosphate No. 2	0.79	0.85	0.47	2.11	*2.06*	11.18	3.08	8.10	*8.00*		
A	388	Ammoniated Wheat and Corn Phosphate No. 2	0.87	0.83	0.38	2.08	*2.06*	11.35	3.24	8.11	*8.00*		
A	548	Ammoniated Wheat and Corn Phosphate No. 2	1.08	0.65	0.29	2.02	*2.06*	11.45	4.12	**7.33**	*8.00*		
A	856	Bean Grower	0.88	0.61	0.32	1.81	*1.65*	11.05	2.98	8 07	*8.00*	1.74	*1.00*
A	913	Complete Fertilizer	0.63	0.16	0.12	0.91	*0.82*	13.45	2.36	11.09	*10.00*	1.30	*1.00*
A	846	Dissolved Bone Phosphate						15.80	1.70	14.10	*14.00*		
A	975	Extra Phos Formula						21.50	2.14	19.36	*18.00*		
A	254	General Crop Phosphate	0.40	0.32	0.22	0.94	*0.82*	10.30	2.10	8.20	*7.00*	1.27	*1.00*
A	293	General Crop Phosphate	0.49	0.35	0.13	0.97	*0.82*	10.55	1.48	9.07	*7.00*	0.89	*1.00*
A	845	General Crop Phosphate	0.56	0.38	0.16	1.10	*0.82*	10.40	1.46	9.04	*7.00*	1.02	*1.00*
A	954	High Grade Phosphate						19.40	1.20	18.20	*16.00*		
A	877	New Rival Ammoniated Superphosphate 1916	0.44	0.21	0.15	0.80	*0.82*	11.20	1.16	10.04	*9.00*	1.11	*1.00*
A	390	Sugar Beet Fertilizer	0.45	0.14	0.34	0.93	*0.82*	11.80	1.86	9.94	*9.00*	0.90	*1.00*
A	279	Universal Grain Grower 1916	0.51	0.29	0.13	0.93	*0.82*	11.70	1.66	10.04	*8.00*	1.26	*1.00*
		Michigan Carbon Works Brands.											
A	295	A 1 Potash Fertilizer 1916	0.41	0.34	0.20	0.95	*0.82*	11.75	1.40	10.35	*8.00*	0.97	*1.00*
A	308	A 1 Potash Fertilizer 1916	0.50	0.31	0.17	0.98	*0.82*	11.20	2.04	9.16	*8.00*	1.00	*1.00*
A	313	A 1 Potash Fertilizer 1916	0.43	0.29	0.15	0.87	*0.82*	12.00	1.24	10.76	*8.00*	1.00	*1.00*
A	319	A 1 Potash Fertilizer 1916	0.48	0.33	0.18	0.99	*0.82*	11.90	1.68	10.22	*8.00*	1.04	*1.00*
A	354	A 1 Potash Fertilizer 1916	0.45	0.33	0.15	0.93	*0.82*	11.05	1.12	9.93	*8.00*	1.00	*1.00*
A	607	A 1 Potash Fertilizer 1916	0.54	0.20	0.24	0.98	*0.82*	11.20	3.12	8.08	*8.00*	0.87	*1.00*
A	543	Banner Bone Phosphate Compound						21.30	1.84	19.46	*18.00*		
A	380	New Standard Ferilizer	0.55	0.20	0.23	0.98	*0.82*	12.65	1.14	11.51	*10.00*		
A	475	New Standard Fertilizer	0.39	0.27	0.24	0.90	*0.82*	13.65	1.66	11.99	*10.00*		

*Total Phosphoric Acid.

ANALYSES OF COMMERCIAL FERTILIZERS FOR 1916, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory number.	Manufacturer and Trade Name.	Nitrogen.					Phosphoric Acid.				Potash.	
		As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total found.	*Total guaranteed.*	Total found.	Insoluble.	Available found.	*Available guaranteed.*	Total found.	*Total guaranteed.*
	Michigan Carbon Works Brand.—Con.											
A 497	New Standard Fertilizer	0.51	0.25	0.26	1.02	*0.82*	12.65	1.84	10.81	*10.00*	......	......
A 518	New Standard Fertilizer	0.53	0.27	0.22	1.02	*0.82*	13.35	1.62	11.73	*10.00*	......	......
A 608	New Standard Fertilizer	0.54	0.19	0.29	1.02	*0.82*	13.15	1.58	11.57	*10.00*	......	......
A 813	New Standard Fertilizer	0.55	0.23	0.26	1.04	*0.82*	12.90	1.14	11.76	*10.00*	......	......
A 413	Red Line Complete Manure	0.44	0.32	0.19	0.95	*0.82*	10.60	1.50	9.10	*7.00*	1.47	*1.00*
A 418	Red Line Complete Manure	0.50	0.30	0.18	0.98	*0.82*	10.70	2.64	8.06	*7.00*	1.25	*1.00*
A 519	Red Line Complete Manure	0.40	0.25	0.22	0.87	*0.82*	10.45	1.24	9.21	*7.00*	1.26	*1.00*
A 833	Red Line Complete Manure	0.49	0.34	0.19	1.02	*0.82*	10.60	1.50	9.10	*7.00*	1.14	*1.00*
A 240	Red Line Phosphate	......	......	......	......	......	17.03	1.48	15.55	*14.00*	......	......
A 294	Red Line Phosphate	......	......	......	......	......	17.65	1.56	16.09	*14.00*	......	......
A 476	Red Line Phosphate	......	......	......	......	......	16.70	2.20	14.50	*14.00*	......	......
A 351	Superior Acid Phosphate	......	......	......	......	......	18.55	1.58	16.97	*16.00*	......	......
A 544	Superior Acid Phosphate	......	......	......	......	......	19.15	1.98	17.17	*16.00*	......	......
A 545	Superior Acid Phosphate	......	......	......	......	......	19.05	1.18	17.87	*16.00*	......	......
A 866	Triaton Fertilizer	1.12	0.26	0.33	1.71	*1.65*	14.60	1.66	12.94	*12.00*	......	......
A 296	Wolverine Phosphate	......	......	......	......	......	11.95	1.54	10.41	*10.00*	......	......
A 564	Wolverine Phosphate	......	......	......	......	......	13.30	2.08	11.22	*10.00*	......	......
	Michigan Carbon Works Homestead Brands.											
A 417	Bean Fertilizer 1916	0.90	0.57	0.38	1.85	*1.65*	11.10	2.32	8.78	*8.00*	1.46	*1.00*
A 876	Bean Fertilizer 1916	0.78	0.51	0.44	1.73	*1.65*	11.00	2.84	8.16	*8.00*	1.43	*1.00*
A 302	Bialode Fertilizer	0.48	0.37	0.10	0.95	*0.82*	12.90	1.38	11.52	*10.00*	1.15	*1.00*
A 350	Bialode Fertilizer	0.43	0.29	0.12	0.84	*0.82*	13.35	1.66	11.69	*10.00*	1.00	*1.00*
A 601	Bialode Fertilizer	0.41	0.30	0.17	0.88	*0.82*	11.90	1.32	10.58	*10.00*	1.06	*1.00*
A 307	Bone Black Fertilizer No. 1	1.02	0.66	0.44	2.12	*2.06*	12.15	4.12	8.03	*8.00*	1.05	*1.00*

A	352	Bone Black Fertilizer No. 1	1.17	0.63	0.39	2.19	2.06	11.15	2.91	8.24	8.00	1.13	1.00
A	602	Bone Black Fertilizer No. 1	1.01	0.55	0.40	1.96	2.06	12.30	3.82	8.48	8.00	1.03	1.00
A	270	Bone Black Fertilizer No. 2	1.28	0.43	0.70	2.41	2.06	10.85	2.64	8.21	8.00		
A	292	Bone Black Fertilizer No. 2	1.13	0.74	0.47	2.34	2.06	10.85	3.41	7.44	8.00		
A	320	Bone Black Fertilizer No. 2	1.01	0.69	0.58	2.28	2.06	11.30	3.30	8.00	8.00		
A	606	Bone Black Fertilizer No. 2	0.79	0.82	0.50	2.11	2.06	11.50	3.58	7.92	8.00		
	10164	Bone Black Sugar Beet Fertilizer	0.47	0.26	0.24	0.97	0.82	11.70	1.96	9.74	9.00	1.08	1.00
A	334	Sugar Beet Fertilizer 1916	0.40	0.34	0.24	0.98	0.82	12.05	1.66	10.39	9.00	1.06	1.00
A	353	Sugar Beet Fertilizer 1916	0.47	0.29	0.15	0.91	0.82	11.95	1.66	10.29	9.00	1.00	1.00
A	847	Sugar Beet Fertilizer 1916	0.69	0.55	0.31	1.55	0.82	11.75	2.70	9.05	9.00	1.58	1.00
A	865	Sugar Beet Fertilizer 1916	0.61	0.29	0.15	1.05	0.82	11.70	1.74	9.96	9.00	0.93	1.00
		Niagara Brands.											
A	971	Acid Phosphate 10%						13.05	1.94	11.11	10.00		
	10165	Bean Grower	0.85	0.65	0.42	1.92	1.65	11.65	2.96	8.69	8.00	1.34	1.00
A	818	Dissolved Bone Phosphate						16.88	1.34	15.54	14.00		
A	842	Dissolved Bone Phosphate						17.05	1.60	15.45	14.00		
	10166	Extra Phos Fertilizer						21 35	1.88	19.47	18.00		
	10167	General Crop Fertilizer	0.41	0.27	0.26	0.94	0.82	12.80	1.24	11.56	10.00	1.05	1.00
A	465	Grain and Grass Grower	0.45	0.32	0.16	0.93	0.82	10.10	1.74	8.36	7.00	1.40	1.00
A	561	Grain and Grass Grower	0.25	0.37	0.21	0.83	0.82	10.30	1.24	9.06	7.00	1.17	1.00
	10168	High Grade Phosphate						19.15	1.88	17.27	16.00		
A	234	Wheat and Corn Producer 1916	0.60	0.27	0.24	1.11	0.82	12.05	1.34	10.71	9.00	0.87	1.00
A	466	Wheat and Corn Producer 1916	0.47	0.31	0.15	0.93	0.82	11.35	1.34	10.01	9.00	1.42	1.00
A	840	Wheat and Corn Producer 1916	0.46	0.33	0.16	0.95	0.82	11.35	1.10	10.25	9.00	0.97	1.00
		North Western Horse Shoe Brands.											
A	312	Acidulated Bone Phosphate and Potash	0.42	0.32	0.18	0.92	0.82	12.75	1.58	11.17	10.00	1.13	1.00
A	803	Acidulated Bone Phosphate and Potash	0.48	0.36	0.18	1.02	0.82	12.95	2.32	10.63	10.00	0.92	1.00
A	311	Animal Bone Phosphate Manure	0.48	0.36	0.14	0.98	0.82	10.50	2.10	8.40	7.00	1.22	1.00
A	801	Animal Bone Phosphate Manure	0.36	0.32	0.19	0.87	0.82	9.95	1.28	8.67	7.00	1.25	1.00
A	547	Bean Special 1916	0.91	0.54	0.40	1.85	1.65	10.98	3.23	7.75	8.00	1.35	1.00
A	225	Corn and Wheat Grower 1916	0.87	0.60	0.48	1.95	1.65	11.33	3.34	7.99	8.00	1.37	1.00
A	802	Corn and Wheat Grower 1916	0.86	0.65	0.36	1.87	1.65	10.45	2.46	7.99	8.00	1.07	1.00
A	386	Corn and Wheat Grower No. 2	1.20	0.76	0.36	2.32	2.06	11.10	1.92	9.18	8.00		
A	489	Corn and Wheat Grower No. 2	0.87	0.99	0.29	2.15	2.06	10.88	2.76	8.12	8.00		
A	474	Dissolved Ammoniated Bone Phosphate	1.40	0.22	0.22	1.84	1.65	14.50	1.64	12.86	12.00		
A	491	Dissolved Ammoniated Bone Phosphate	0.88	0.54	0.32	1.74	1.65	15.95	1.94	14.01	12.00		
A	263	F. and F. Fertilizer	0.61	0.23	0.20	1.04	0.82	13.25	1.38	11.87	10.00		
A	290	F. and F. Fertilizer	0.52	0.40	0.12	1.04	0.82	12.15	2.19	9.96	10.00		
A	367	F. and F. Fertilizer	0.46	0.40	0.14	1.00	0.82	12.85	2.38	10.47	10.00		
A	372	F. and F. Fertilizer	0.44	0.36	0.15	0.95	0.82	12.23	2.32	9.91	10.00		

ANALYSES OF COMMERCIAL FERTILIZERS FOR 1916, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory number.	Manufacturer and Trade Name.	Nitrogen. As soluble.	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total found.	Nitrogen. *Total guaranteed.*	Phosphoric Acid. Total found.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Available found.	Phosphoric Acid. *Available guaranteed.*	Potash. Total found.	Potash. *Total guaranteed.*
	North Western Horse Shoe Brands.—Con.											
A 905	18% Fertilizer	....	....	....	....	....	23.70	4.24	19.46	*18.00*	....	....
A 385	Garden City Superphosphate 1916	1.06	0.75	0.42	2.23	*2.06*	11.75	3.59	8.16	*8.00*	0.95	*1.00*
A 488	Garden City Superphosphate 1916	1.00	0.74	0.48	2.22	*2.06*	11.53	4.10	**7.43**	*8.00*	1.13	*1.00*
A 843	16% Acid Phosphate	....	....	....	....	....	18.95	2.86	16.09	*16.00*	....	....
A 224	Potash Manure 1916	0.44	0.35	0.21	1.00	*0.82*	12.43	1.52	10.91	*8.00*	1.20	*1.00*
A 262	Potash Manure 1916	0.48	0.33	0.23	1.04	*0.82*	11.40	2.02	9.38	*8.00*	0.90	*1.00*
A 364	Potash Manure 1916	0.47	0.25	0.22	0.94	*0.82*	11.65	1.12	10.53	*8.00*	1.02	*1.00*
A 473	Potash Manure 1916	0.56	0.29	0.17	1.02	*0.82*	12.80	1.48	11.32	*8.00*	1.00	*1.00*
A 492	Potash Manure 1916	0.44	0.29	0.24	0.97	*0.82*	11.20	1.44	9.76	*8.00*	0.84	*1.00*
A 365	Quick Acting Phosphate	....	....	....	....	....	12.35	1.54	10.81	*10.00*	....	....
A 366	Square Deal Phosphate	....	....	....	....	....	17.50	1.70	15.20	*14.00*	....	....
	Sugar Beet Fertilizer 1916	....	....	....	....	*0.82*	....	....	....	*9.00*	....	*1.00*
	Packers Boar's Head Brands.											
A 541	Ammoniated Bone Phosphate and Potash	0.41	0.33	0.16	0.90	*0.82*	13.75	2.00	11.75	*10.00*	1.24	*1.00*
A 463	Corn and Wheat Grower 1916	0.96	0.51	0.50	1.97	*1.65*	11.35	3.32	8.03	*8.00*	1.15	*1.00*
A 244	Corn and Wheat Grower No. 2	0.94	0.88	0.38	2.20	*2.06*	11.35	2.94	8.41	*8.00*	....	....
A 464	Corn and Wheat Grower No. 2	0.93	0.88	0.48	2.29	*2.06*	11.38	3.36	8.02	*8.00*	....	....
A 462	Extra Bone Phosphate Formula	....	....	....	....	....	21.80	2.00	19.80	*18.00*	....	....
A 412	Faultless Grain Grower	0.44	0.28	0.18	0.90	*0.82*	10.55	1.42	9.13	*7.00*	1.40	*1.00*
A 456	Faultless Grain Grower	0.39	0.30	0.15	0.84	*0.82*	10.30	1.74	8.56	*7.00*	1.15	*1.00*
A 966	Gilt Edge Phosphate 1916	....	....	....	....	....	18.10	3.28	14.82	*14.00*	....	....
A 232	New Compound	0.41	0.24	0.26	0.91	*0.82*	12.45	1.58	10.87	*10.00*	....	....
A 281	New Compound	0.48	0.27	0.23	0.98	*0.82*	13.15	2.04	11.11	*10.00*	....	....
A 309	New Compound	0.60	0.24	0.21	1.05	*0.82*	13.20	1.54	11.66	*10.00*	....	....
A 332	New Compound	0.59	0.22	0.20	1.01	*0.82*	12.80	1.34	10.46	*10.00*	....	....

A	282	Soluble Phosphate	...	...	...	...	...	11.80	1.38	10.42	*10.00*	...	...
A	542	Sugar Beet Grower 1916	0.44	0.28	0.26	0.98	*0.82*	13.00	0.86	12.14	*9.00*	1.49	*1.00*
A	280	Sure Growth Potash Manure 1916	0.51	0.28	0.21	1.00	*0.82*	11.50	2.16	9.34	*8.00*	1.22	*1.00*
A	383	Sure Growth Potash Manure 1916	0.49	0.22	0.19	0.90	*0.82*	11.80	1.34	10.46	*8.00*	0.97	*1.00*
A	500	Sure Growth Potash Manure 1916	0.49	0.25	0.23	0.97	*0.82*	12.30	1.52	10.78	*8.00*	0.86	*1.00*
A	455	Sure Growth Potash Manure 1916	0.49	0.33	0.16	0.98	*0.82*	11.35	1.04	10.31	*8.00*	1.01	*1.00*
A	961	World of Good Superphosphate 1916	1.23	0.75	0.36	2.34	*2.06*	13.90	3.84	10.06	*8.00*	1.18	*1.00*
A	331	16% Phosphate	...	...	...	...	...	18.90	2.12	16.78	*16.00*	...	...
A	575	16% Phosphate	...	...	...	...	...	19.85	1.74	18.11	*16.00*	...	...
		Ann Arbor Abattoir Co., Ann Arbor, Mich.											
	11717	Three A Blood and Bone Meal	4.76	1.65	1.06	7.47	*7.12*	**13.75**	...	...	**15.82*	...	...
		Armour Fertilizer Works, Chicago, Ill.											
A	382	16% Acid Phosphate	...	...	...	...	...	17.10	0.48	16.62	*16.00*	...	...
A	396	16% Acid Phosphate	...	...	...	...	...	17.05	0.08	16.97	*16.00*	...	...
A	485	16% Acid Phosphate	...	...	...	...	...	17.60	0.24	17.36	*16.00*	...	...
A	395	Ammoniated Phosphate No. 2	0.80	0.45	0.38	1.63	*1.65*	12.55	2.71	9.84	*10.00*	...	...
A	454	Ammoniated Phosphate No. 2	0.96	0.45	0.35	1.76	*1.65*	13.00	1.92	11.08	*10.00*	...	...
A	511	Bone Meal	0.37	1.15	0.45	1.97	*1.65*	28.20	...	...	**27.00*	...	...
A	578	Bone Meal	0.32	0.73	0.78	1.63	*1.65*	27.00	...	...	**27.00*	...	...
A	573	Grain Grower	0.67	0.33	0.66	1.66	*1.65*	10.35	1.00	9.35	*8.00*	2.17	*2.00*
A	899	Grain Grower	0.86	0.32	0.63	1.81	*1.65*	11.30	1.66	9.64	*8.00*	1.95	*2.00*
A	837	Grain and Bean Special	0.37	0.17	0.37	0.91	*0.82*	9.75	1.14	8.61	*8.00*	**1.59**	*2.00*
A	839	Grain and Bean Special	0.27	0.49	0.35	1.11	*0.82*	10.50	1.64	8.86	*8.00*	1.90	*2.00*
A	929	Grain and Bean Special	0.49	0.19	0.48	1.16	*0.82*	9.60	1.20	8.40	*8.00*	**1.62**	*2.00*
A	362	Michigan Special	0.41	0.23	0.33	0.97	*0.82*	10.55	1.54	9.01	*8.00*	0.97	*1.00*
A	381	Michigan Special	0.60	0.16	0.28	1.04	*0.82*	10.20	1.24	8.96	*8.00*	0.99	*1.00*
A	436	Michigan Special	0.51	0.19	0.23	0.93	*0.82*	10.20	1.34	8.86	*8.00*	0.84	*1.00*
A	453	Michigan Special	0.38	0.26	0.26	0.90	*0.82*	10.95	1.32	9.63	*8.00*	0.95	*1.00*
A	486	Michigan Special	0.38	0.23	0.29	0.90	*0.82*	10.90	1.12	9.78	*8.00*	0.87	*1.00*
A	807	Michigan Special	0.39	0.23	0.28	0.90	*0.82*	9.96	1.10	8.85	*8.00*	1.00	*1.00*
A	920	Phosphate & Potash	...	...	...	...	...	10.65	0.32	10.33	*10.00*	**1.71**	*2.00*
A	932	Phosphate & Potash	...	...	...	...	...	12.15	0.34	11.81	*10.00*	**1.37**	*2.00*
A	570	Potash & Phosphate Special	...	...	...	...	...	11.30	0.94	10.36	*10.00*	**0.66**	*1.00*
A	930	Potash & Phosphate Special	...	...	...	...	...	11.25	0.82	10.43	*10.00*	0.85	*1.00*
	10169	Special Celery & Truck Grower	0.94	1.54	0.80	3.27	*3.30*	9.90	0.26	9.64	*8.00*	1.26	*1.00*
A	231	Special Grain Grower	0.65	0.51	0.44	1.60	*1.65*	11.65	2.86	8.79	*8.00*	1.25	*1.00*

*Total Phosphoric Acid.

ANALYSES OF COMMERCIAL FERTILIZERS FOR 1916, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory number.	Manufacturer and Trade Name.	Nitrogen.					Phosphoric Acid.				Potash.	
		As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total found.	*Total guaranteed.*	Total found.	Insoluble.	Available found.	*Available guaranteed.*	Total found.	*Total guaranteed.*
	Armour Fertilizer Works.—Con.											
A 276	Special Grain Grower	0.60	0.35	0.53	1.48	*1.65*	10.90	2.20	8.70	*8.00*	1.02	*1.00*
A 286	Special Grain Grower	0.71	0.44	0.48	1.63	*1.65*	10.70	2.06	8.64	*8.00*	0.98	*1.00*
A 322	Special Grain Grower	0.84	0.39	0.45	1.68	*1.65*	10.85	2.22	8.63	*8.00*	1.07	*1.00*
A 323	Special Grain Grower	0.86	0.46	0.56	1.88	*1.65*	11.05	1.54	9.51	*8.00*	0.99	*1.00*
A 484	Special Grain Grower	0.80	0.49	0.49	1.78	*1.65*	10.90	2.40	8.50	*8.00*	1.20	*1.00*
A 493	Special Grain Grower	0.71	0.42	0.50	1.63	*1.65*	11.45	2.62	8.83	*8.00*	1.11	*1.00*
A 496	Special Grain Grower	0.81	0.44	0.55	1.80	*1.65*	11.00	2.40	8.60	*8.00*	1.01	*1.00*
A 509	Special Grain Grower	0.77	0.46	0.45	1.68	*1.65*	10.73	1.92	8.81	*8.00*	1.01	*1.00*
A 537	Standard	0.46	0.21	0.26	0.93	*0.82*	9.55	0.92	8.63	*8.00*	3.01	*3.00*
A 928	Standard	0.62	0.18	0.43	1.23	*0.82*	9.35	1.28	8.07	*8.00*	2.07	*3.00*
A 363	Star Phosphate	.....	.....	.....	.....	.....	15.50	0.46	15.04	*14.00*	.....	.....
A 495	Star Phosphate	.....	.....	.....	.....	.....	16.45	0.34	16.11	*14.00*	.....	.....
A 534	Star Phosphate	.....	.....	.....	.....	.....	14.90	0.08	14.82	*14.00*	.....	.....
A 230	Wheat, Corn & Oats Special	0.40	0.29	0.22	0.91	*0.82*	9.20	1.32	7.88	*7.00*	0.94	*1.00*
A 246	Wheat, Corn & Oats Special	0.35	0.27	0.42	1.04	*0.82*	9.00	1.60	7.40	*7.00*	1.03	*1.00*
A 285	Wheat, Corn & Oats Special	0.35	0.22	0.20	0.97	*0.82*	8.75	1.04	7.71	*7.00*	1.00	*1.00*
A 321	Wheat, Corn & Oats Special	0.39	0.26	0.26	0.91	*0.82*	8.70	0.54	8.16	*7.00*	1.04	*1.00*
A 450	Wheat, Corn & Oats Special	0.51	0.19	0.31	1.01	*0.82*	8.75	1.18	7.57	*7.00*	0.79	*1.00*
A 510	Wheat, Corn & Oats Special	0.39	0.25	0.22	0.86	*0.82*	8.20	1.18	7.02	*7.00*	0.96	*1.00*
101610	5-8 Fertilizer	1.11	1.62	1.40	4.13	*4.13*	11.65	2.56	9.09	*8.00*	.....	.....
A 933	1-9-1 Fertilizer	0.55	0.18	0.29	1.02	*0.82*	10.90	0.86	10.04	*9.00*	1.32	*1.00*
A 574	1-12-1 Fertilizer	0.45	0.17	0.38	1.00	*0.82*	13.65	1.14	12.51	*12.00*	1.36	*1.00*
A 926	1-12-1 Fertilizer	0.37	0.18	0.3	.94	*0.82*	13.50	1.22	12.28	*12.00*	1.55	*1.00*
A 925	1-14-2 Fertilizer	0.41	0.31	0.25	0.97	*0.82*	16.10	1.24	14.86	*14.00*	1.85	*2.00*
A 937	1-14-2 Fertilizer	0.50	0.25	0.30	1.05	*0.82*	15.50	1.28	14.22	*14.00*	1.92	*2.00*
A 555	2-10-2 Fertilizer	0.69	0.30	0.62	1.61	*1.65*	12.00	1.54	10.46	*10.00*	2.23	*2.00*
A 924	2-10-2 Fertilizer	0.83	0.46	0.54	1.83	*1.65*	12.65	1.70	10.95	*10.00*	2.02	*2 00*

A	245	3-8-1 Fertilizer	1.23	0.64	0.60	2.47	*2.47*	10.95	2.20	8.75	*8.00*	1.04	*1.00*
A	494	3-8-1 Fertilizer	1.50	0.56	0.65	2.71	*2.47*	11.10	2.12	8.98	*8.00*	1.08	*1.00*
A	521	3-8-1 Fertilizer	1.28	0.55	0.52	**2.35**	*2.47*	11.95	2.12	9.83	*8.00*	1.02	*1.00*
		R. Binder Co., Battle Creek, Mich.											
A	597	Blood & Bone	4.18	1.33	0.68	6.19	*5.25*	14.80	....	....	**11.87*	....	....
		James Boland Rendering & Fertilizer Co., Jackson, Mich.											
A	256	Blackman Special Fertilizer	0.39	0.80	0.47	**1.66**	*2.00*	19.05	4.92	14.13	**13.00*	....	....
		E. Burton, St. Joseph, Mich.											
A	490	Meat & Bone Phosphate	0.85	2.10	1.22	**4.17**	*5.00*	14.33	6.88	7.45	*6.00*	....	....
		Chicago Feed & Fertilizer Co., Chicago, Ill.											
A	824	Magic 4-3-1	0.28	1.22	1.34	**2.84**	*3.29*	4.80	2.98	1.82	*2.00*	1.00	*0.83*
	101612	Magic 4-6-1	0.28	2.62	0.90	3.80	*3.29*	9.00	4.38	4.62	*4.50*	1.19	*0.83*
	101613	Magic 6-14 Blood and Bone	1.06	2.68	1.64	5.38	*4.94*	17.90	12.33	**5.57**	*9.00*	....	....
	101614	Magic 3-23 Steamed Bone Meal	1.19	1.17	0.14	2.50	*2.47*	21.78	15.10	**6.65**	*10.50*	....	....
		Chicago Raw Products Co., Chicago, Ill.											
A	375	Consumers Ammoniated Phosphate & Potash	0.31	0.22	0.58	1.11	*0.82*	11.35	1.36	9.99	*10.00*	1.06	*1.00*
A	374	Consumers Bone Phosphate & Potash Mixture	0.17	0.23	0.50	0.90	*0.41*	11.55	1.54	10.01	*10.00*	1.09	*1.00*
A	863	Consumers Bone Phosphate & Potash Mixture	0.35	0.21	0.30	0.86	*0.41*	13.15	1.14	12.01	*10.00*	0.80	*1.00*
		Darling & Co., Chicago, Ill.											
A	360	16% Acid Phosphate	....	....	....	....	....	21.55	2.10	19.45	*16.00*	....	....
A	422	16% Acid Phosphate	....	....	....	....	....	21.05	3.03	18.02	*16.00*	....	....
A	477	16% Acid Phosphate	....	....	....	....	....	20.50	2.60	17.90	*16.00*	....	....
A	252	Big Harvest	0.42	0.87	0.61	1.90	*1.65*	15.75	2.54	13.21	*12.00*	0.92	*1.00*
A	411	Big Harvest	0.42	0.78	0.65	1.85	*1.65*	15.40	2.52	12.88	*12.00*	1.00	*1.00*
A	830	Big Harvest	0.45	0.79	0.54	1.78	*1.65*	15.85	2.04	13.81	*12.00*	0.96	*1.00*
A	405	Farmer's Favorite	0.39	1.22	0.72	2.43	*2.47*	14.20	5.54	8.66	*8.00*	1.01	*1.00*
A	424	Farmers' Favorite	0.49	0.74	1.00	**2.23**	*2.47*	13.30	4.68	8.62	*8.00*	1.50	*1.00*
A	478	Farmers' Favorite	0.53	1.23	0.91	2.67	*2.47*	14.00	4.56	9.44	*8.00*	1.00	*1.00*
A	409	Grain Grower	0.27	0.25	0.42	0.94	*0.82*	13.75	1.78	11.97	*9.00*	1.28	*1.00*
A	425	Grain Grower	0.14	0.36	0.43	0.93	*0.82*	12.60	1.90	10.70	*9.00*	0.98	*1.00*
A	609	Grain Grower	0.25	0.31	0.37	0.93	*0.82*	12.30	2.06	10.24	*9.00*	0.96	*1.00*
A	591	Half & Half Brand	0.05	0.47	0.33	0.95	*0.82*	24.78	14.20	**10.58**	*12.00*	....	....
A	927	Half & Half Brand	0.30	0.52	0.37	1.19	*0.82*	26.05	14.98	**11.07**	*12.00*	....	....

*Total Phosphoric Acid.

ANALYSES OF COMMERCIAL FERTILIZERS FOR 1916, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory number.	Manufacturer and Trade Name.	Nitrogen.					Phosphoric Acid.				Potash.	
		As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total found.	*Total guaranteed.*	Total found.	Insoluble.	Available found.	*Available guaranteed.*	Total found.	*Total guaranteed.*
	Darling & Co.—Con.											
A 407	Pulverized Sheep Manure	0.42	0.61	0.58	1.61	*2.06*	1.35	0.18	1.17	*1.00*	1.08	*1.00*
A 426	Pulverized Sheep Manure	0.71	0.53	1.33	2.54	*2.06*	1.90	0.26	1.64	*1.00*	2.04	*1.00*
A 480	Pulverized Sheep Manure	0.66	0.56	1.36	2.58	*2.06*	2.25	0.60	1.65	*1.00*	1.88	*1.00*
A 448	Pure Bone & Potash	0.19	1.09	0.50	1.78	*1.65*	26.90	......	......	**27.00*	3.07	*2.00*
A 423	Pure Ground Bone	0.40	1.09	0.70	2.19	*1.85*	28.60	......	......	**28.00*	......	......
A 404	Pure Ground Bone	0.26	1.13	0.61	2.00	*1.85*	28.88	......	......	**28.00*	......	......
A 829	Pure Ground Bone	0.47	1.09	0.55	2.11	*1.85*	28.25	......	......	**28.00*	......	......
A 397	Sure Crop	0.30	0.74	0.74	1.78	*1.65*	17.80	3.92	13.88	*12.00*	......	......
A 406	Sure Crop	0.35	0.82	0.68	1.85	*1.65*	16.90	3.98	12.92	*12.00*	......	......
A 359	Sure Winner	0.19	0.36	0.38	0.93	*0.82*	14.80	3.70	11.10	*10.00*	0.78	*0.50*
A 410	Sure Winner	0.19	0.55	0.54	1.28	*0.82*	13.90	3.80	10.10	*10.00*	0.57	*0.50*
A 497	Sure Winner	0.10	0.33	0.37	0.80	*0.82*	13.60	2.86	10.74	*10.00*	0.45	*0.50*
A 483	Sure Winner	0.10	0.33	0.32	0.75	*0.82*	14.25	2.88	11.37	*10.00*	0.52	*0.50*
A 610	Sure Winner	0.20	0.36	0.41	0.97	*0.82*	14.28	4.22	10.06	*10.00*	0.50	*0.50*
	Farmers Fertilizer Co., Columbus, O.											
	Lillies Brands.											
A 954	Eureka	0.45	0.10	0.20	0.75	*0.80*	14.40	1.28	9.12	*8.00*	1.82	*2.00*
A 468	Special No. 1	0.44	0.16	0.31	0.91	*0.80*	13.25	0.76	12.49	*11.00*	......	......
A 470	Special No. 2	1.03	0.37	0.30	1.70	*1.60*	11.65	3.18	8.47	*8.00*	1.20	*1.00*
A 853	Special No. 2	0.53	0.65	0.29	1.47	*1.60*	11.65	2.26	9.39	*8.00*	1.15	*1.00*
A 305	Special No. 3	0.70	0.22	0.19	1.11	*0.80*	12.85	2.06	10.79	*9.00*	1.00	*1.00*
A 471	Special No. 3	0.58	0.19	0.28	1.05	*0.80*	11.38	1.86	9.52	*9.00*	1.03	*1.00*
A 815	Special No. 3	0.57	0.14	0.19	0.90	*0.80*	10.80	1.58	9.22	*9.00*	1.10	*1.00*
A 304	Reliable Phosphate	......	......	......	......	......	18.20	0.34	17.86	*14.00*	......	......
A 306	Reliable Phosphate	......	......	......	......	......	15.75	1.10	14.65	*14.00*	......	......

A	437	Reliable Phosphate	....	....	....	....	....	15.05	0.34	14.71	*14.00*	....	....
A	439	General Crop	0.49	0.12	0.23	0.84	*0.80*	9.70	0.60	9.10	*7.00*	0.99	*1.00*
A	469	General Crop	0.47	0.15	0.29	0.91	*0.80*	9.90	1.36	8.54	*7.00*	0.97	*1.00*
A	814	General Crop	0.25	0.16	0.31	0.72	*0.80*	10.08	2.48	7.60	*7.00*	1.33	*1.00*
A	854	General Crop	0.50	0.29	0.26	1.05	*0.80*	10.05	1.74	8.31	*7.00*	1.14	*1.00*
A	349	Surprise	0.49	0.34	0.27	**1.10**	*1.60*	14.60	1.66	12.94	*10.00*	....	....
A	438	Surprise	0.44	0.53	0.52	**1.49**	*1.60*	13.53	1.34	12.19	*10.00*	....	....
A	855	Surprise	0.71	0.46	0.46	1.63	*1.60*	11.90	1.48	10.42	*10.00*	....	....
	101615	Humus Chief	0.17	0.12	0.12	0.41	*0.40*	15.25	1.38	13.87	*12.50*	....	....
		Grand Rapids Glue Co., Grand Rapids, Mich.											
	101616	Grand Rapids	0.95	0.78	0.40	2.13	*2.00*	15.65	12.68	**2.97**	*5.00*	0.31	*0.05*
		Grange Fertilizer Co., Detroit, Mich.											
		Michigan Grange Brands.											
A	974	All Crops Special Fertilizer 1916	0.39	0.27	0.31	0.97	*0.82*	12.90	2.50	10.40	*8.00*	1.22	*1.00*
A	962	Complete Manure	0.73	0.18	0.21	1.12	*0.82*	9.45	1.34	8.11	*7.00*	1.26	*1.00*
A	274	Corn Oats and Grass Fertilizer 1916	0.79	0.56	0.46	1.81	*1.65*	11.00	3.17	7.83	*8.00*	1.15	*1.00*
A	965	Corn Oats and Grass Fertilizer 1916	0.84	0.61	0.35	1.80	*1.65*	13.55	3.94	9.61	*8.00*	1.16	*1.00*
A	958	I X Fertilizer	0.67	0.37	0.18	1.22	*0.82*	14.05	2.78	11.27	*10.00*	....	....
A	964	High Grade Concentrated Wheat Manure 1916	0.53	0.23	0.17	0.93	*0.82*	11.60	1.74	9.86	*9.00*	1.14	*1.00*
A	959	Wheat Fertilizer No. 1	....	....	....	....	....	17.90	1.64	16.26	*14.00*	....	....
A	960	Wheat Fertilizer No. 1	....	....	....	....	....	18.95	2.74	16.21	*14.00*	....	....
A	957	Wheat Fertilizer No. 2	....	....	....	....	....	11.60	1.50	10.10	*10.00*	....	....
		Hirsh Stein & Co., Chicago, Ill.											
		Calumet Brands.											
A	291	14% Acid Phosphate	....	....	....	....	....	15.85	0.58	15.27	*14.00*	....	....
A	849	14% Acid Phosphate	....	....	....	....	....	16.90	0.32	16.58	*14.00*	....	....
A	301	16% Acid Phosphate	....	....	....	....	....	19.45	0.42	19.03	*16.00*	....	....
A	506	Ammoniated Phosphate	0.42	0.66	0.66	1.74	*1.64*	12.40	0.80	11.60	*10.00*	....	....
A	526	Ammoniated Phosphate & Potash	0.35	0.29	0.57	1.21	*0.82*	10.72	1.52	9.20	*10.00*	1.04	*1.00*
A	341	Ammoniated Phosphate & Potash	0.18	0.29	0.48	0.95	*0.82*	11.25	1.46	9.79	*10.00*	1.04	*1.00*
A	391	Ammoniated Phosphate & Potash	0.19	0.16	0.39	0.74	*0.82*	11.28	1.50	9.78	*10.00*	1.00	*1.00*
A	848	Ammoniated Phosphate & Potash	0.15	0.22	0.63	1.00	*0.82*	11.50	1.40	10.10	*10.00*	1.22	*1.00*
		Ammoniated Potash Special	....	....	....	....	*2.06*	....	....	....	*8.00*	....	*1.00*
A	505	Bone & Phosphate Mixture	0.07	0.20	0.15	0.42	*0.41*	24.18	11.92	**12.26**	*15.00*	....	....
A	346	Bone Phosphate & Potash Mixture	0.32	0.09	0.15	0.56	*0.41*	15.55	1.28	14.27	*10.00*	1.28	*1.00*
A	392	Bone Phosphate & Potash Mixture	0.21	0.17	0.43	0.81	*0.41*	12.00	1.40	10.60	*10.00*	1.11	*1.00*

*Total Phosphoric Acid.

ANALYSES OF COMMERCIAL FERTILIZERS FOR 1916, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory number.	Manufacturer and Trade Name.	Nitrogen. As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total found.	*Total guaranteed.*	Phosphoric Acid. Total found.	Insoluble.	Available found.	*Available guaranteed.*	Potash. Total found.	*Total guaranteed.*
	Calumet Brands.—Con.											
A 400	Bone Phosphate & Potash Mixture	0.30	0.24	0.62	1.16	*0.41*	12.45	2.25	10.17	*10.00*	**0.67**	*1.00*
101618	Special Pure Bone Meal	0.41	0.27	0.12	0.80	*0.82*	31.30	....	....	**29.77*	....	....
A 532	Sure Growth Fertilizer	0.70	0.42	0.57	1.69	*0.82*	12.87	6.87	**6.00**	*8.00*	1.87	*2.00*
A 935	Sure Growth Fertilizer	0.61	0.37	0.47	1.45	*0.82*	12.85	5.69	**7.16**	*8.00*	2.04	*2.00*
	The Independent Packers Fertilizer Co., Columbus, Ohio.											
A 342	No. 3, Corn, Wheat, Oats & Clover	0.33	0.16	0.35	0.84	*0.80*	10.55	0.86	9.69	*7.00*	0.95	*1.00*
A 344	No. 3, Corn, Wheat, Oats & Clover	0.38	0.18	0.31	0.87	*0.80*	9.50	1.12	8.38	*7.00*	0.82	*1.00*
A 821	No. 5, Universal Crop	0.63	0.57	0.30	**1.50**	*1.65*	12.45	2.12	10.33	*10.00*	....	....
A 949	No. 6, Truck & Tobacco Grower	0.72	0.36	0.55	1.63	*1.65*	12.15	2.98	9.17	*8.00*	**0.67**	*1.00*
A 940	No. 7, Corn & Wheat Special	0.22	0.07	0.25	**0.54**	*0.82*	14.85	0.96	13.89	*8.00*	**1.35**	*2.00*
A 948	No. 7, Corn & Wheat Special	0.37	0.13	0.47	0.97	*0.82*	11.25	0.82	10.43	*8.00*	1.86	*2.00*
A 822	No. 9, Soluble Phosphate	....	....	....	....	....	15.25	0.12	15.13	*14.00*	....	....
101619	Special Sugar Beet Fertilizer	0.27	0.22	0.24	0.73	*0.82*	10.85	0.96	9.89	*8.00*	1.63	*1.00*
121625	Special Sugar Beet Grower	0.41	1.00	0.56	1.97	*1.65*	13.10	1.90	11.20	*10.00*	....	....
A 811	Sugar Beet Grower	0.28	0.12	0.37	0.77	*0.82*	10.05	1.16	8.89	*8.00*	**1.49**	*2.00*
	International Agricultural Corporation, Lockland, Ohio.											
101622	16% Acid Phosphate	....	....	....	....	....	17.20	0.74	16.46	*16.00*	....	....
A 969	18% Acid Phosphate	....	....	....	....	....	22.10	0.82	21.28	*18.00*	....	....
A 976	18% Acid Phosphate	....	....	....	....	....	20.80	0.54	20.26	*18.00*	....	....
A 447	Bone Meal	0.41	1.57	0.41	2.39	*2.40*	22.55	....	....	**22.00*	....	....
101621	Farmers Favorite	0.27	0.30	0.27	0.84	*0.80*	11.95	1.92	10.03	*10.00*	....	....
A 970	Garbage Tankage & Phosphate	0.17	0.11	0.11	0.39	*0.40*	16.25	1.60	14.65	*12.50*	....	....
A 955	Wheat, Corn & Oats Special	0.39	0.25	0.17	0.81	*0.80*	13.00	2.00	11.00	*10.00*	1.17	*1.00*
A 300	Buffalo Ammoniated Phosphate	0.60	0.59	0.44	1.63	*1.60*	13.70	2.58	11.12	*10.00*	....	....
A 310	Buffalo Buckeye Brand	....	....	....	....	....	13.60	2.38	11.22	*10.00*	1.08	*1.00*

A	908	Buffalo Buckeye Brand	...	...	...	...	...	12.20	1.70	10.50	*10.00*	0.95	*1.00*
A	956	Buffalo Complete Fertilizer	0.85	0.47	0.31	1.63	*1.60*	9.88	2.34	**7.54**	*8.00*	0.87	*1.00*
A	967	Buffalo Complete Fertilizer	0.90	0.23	0.13	**1.26**	*1.60*	9.55	1.30	8.25	*8.00*	0.98	*1.00*
A	298	Buffalo Crop Grower	0.32	0.30	0.21	0.83	*0.80*	12.25	3.54	8.71	*8.00*	1.14	*1.00*
A	850	Buffalo Crop Grower	0.25	0.33	0.25	0.83	*0.80*	13.10	2.06	11.04	*8.00*	0.98	*1.00*
A	299	Buffalo Dissolved Phosphate	...	...	...	...	...	15.50	1.22	14.28	*14.00*	...	...
A	852	Buffalo Dissolved Phosphate	...	...	...	...	...	18.15	0.62	17.53	*14.00*	...	...
	101623	Buffalo Grain Grower	0.27	0.42	0.25	0.94	*0.84*	14.65	0.84	13.81	*13.00*	...	...
		Jarecki Chemical Co., Sandusky, Ohio.											
A	939	Acid Phosphate	...	...	...	...	...	20.05	1.36	18.69	*16.00*	...	...
A	355	Ammoniated Phosphate	0.43	0.27	0.27	0.97	*0.82*	11.55	1.98	**9.57**	*10.00*	...	...
A	446	Ammoniated Phosphate	0.20	0.26	0.22	**0.68**	*0.82*	11.58	1.83	**9.75**	*10.00*	...	...
A	891	Cereala	0.73	0.59	0.37	1.69	*1.65*	15.50	2.56	12.94	*12.00*	...	...
A	284	C. O. D. Phosphate	...	...	...	...	...	16.10	1.16	14.94	*14.00*	...	...
A	872	C. O. D. Phosphate	...	...	...	...	...	16.40	0.84	15.56	*14.00*	...	...
A	283	Lake Erie Guano with Phosphate and Potash	0.45	0.39	0.34	1.18	*1.25*	11.35	1.80	9.55	*9.00*	0.99	*1.00*
A	378	Lake Erie Guano with Phosphate and Potash	0.58	0.38	0.37	1.33	*1.25*	12.00	1.68	10.32	*9.00*	1.13	*1.00*
A	444	Lake Erie Guano with Phosphate and Potash	0.44	0.47	0.37	1.28	*1.25*	12.05	1.96	10.09	*9.00*	1.03	*1.00*
A	520	Lake Erie Guano with Phosphate and Potash	0.50	0.45	0.28	1.23	*1.25*	11.80	1.66	10.14	*9.00*	1.00	*1.00*
A	603	Lake Erie Guano with Phosphate and Potash	0.48	0.36	0.46	1.30	*1.25*	11.90	1.70	10.20	*9.00*	1.11	*1.00*
A	343	Little Giant	0.24	0.22	0.31	0.77	*0.82*	9.05	1.46	7.59	*7.00*	0.99	*1.00*
A	370	Little Giant	0.32	0.23	0.32	0.87	*0.82*	9.65	1.10	8.55	*7.00*	1.03	*1.00*
A	443	Little Giant	0.27	0.23	0.34	0.84	*0.82*	9.70	1.48	8.22	*7.00*	1.08	*1.00*
A	369	Number One Formula	0.41	0.18	0.31	0.90	*0.82*	12.05	3.78	**8.27**	*9.00*	0.84	*1.00*
A	373	Number One Formula	0.33	0.18	0.24	0.75	*0.82*	11.05	1.80	9.25	*9.00*	0.88	*1.00*
A	377	Number One Formula	0.32	0.18	0.34	0.84	*0.82*	11.30	2.99	**8.31**	*9.00*	0.96	*1.00*
A	445	Number One Formula	0.36	0.17	0.33	0.86	*0.82*	11.80	2.08	9.72	*9.00*	0.95	*1.00*
A	892	One Eight Two	0.39	0.12	0.35	0.86	*0.82*	11.85	3.99	7.93	*8.00*	1.89	*2.00*
A	901	One Eight Two	0.36	0.18	0.27	0.81	*0.82*	11.75	3.70	8.05	*8.00*	**1.75**	*2.00*
A	387	Pure Ground Bone	1.75	0.48	0.30	2.53	*2.50*	20.50	...	...	**20.00*	...	...
A	938	Raw Bone and Phosphate Mixture	0.61	0.58	0.49	1.68	*1.65*	17.75	8.88	8.87	*8.00*	1.02	*1.00*
A	314	Special Sugar Beet Grower	0.42	0.21	0.28	0.91	*0.82*	12.15	2.30	9.85	*9.00*	1.13	*1.00*
A	269	Tobacco & Truck Grower	0.79	0.58	0.48	1.85	*1.65*	10.60	2.50	8.10	*8.00*	0.98	*1.00*
A	330	Tobacco & Truck Grower	0.60	0.56	0.57	1.73	*1.65*	10.05	2.19	7.86	*8.00*	0.89	*1.00*
A	371	Tobacco & Truck Grower	0.61	0.62	0.48	1.71	*1.65*	10.00	1.88	8.12	*8.00*	1.02	*1.00*
A	376	Tobacco & Truck Grower	0.49	0.58	0.55	1.62	*1. 5*	9.95	2.49	**7.46**	*8.00*	1.00	*1.00*

*Total Phosphoric Acid.

ANALYSES OF COMMERCIAL FERTILIZERS FOR 1916, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory number.	Manufacturer and Trade Name.	Nitrogen.					Phosphoric Acid.				Potash.	
		As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total found.	*Total guaranteed.*	Total found.	Insoluble.	Available found.	*Available guaranteed.*	Total found.	*Total guaranteed.*
	Kalamazoo Rendering & Fertilizer Co. Kalamazoo, Mich.											
A 533	Kalferco	0.80	0.99	0.77	2. 6	*1.65*	13.53	11.67	1.86	*8.00*	1.11	*1.00*
A 596	Kazoo Brand	1.38	0.56	0.46	2.40	*2.00*	15.65	5.62	10.03	*10.00*	……	……
	Mineral Fertilizer Co., Chicago, Ill.											
A 235	Nu-Life Fertilizer	……	……	……	……	……	15.15	……	1.80	**15.00*	……	……
A 273	Nu-Life Fertilizer	……	……	……	……	……	14.70	13.30	1.40	**15.00*	……	……
A 379	Nu-Life Fertilizer	……	……	……	……	……	13.05	……	1.80	**15.00*	……	……
A 384	Nu-Life Fertilizer	……	……	……	……	……	12.50	……	1.64	**15.00*	……	……
A 530	Nu-Life Fertilizer	……	……	……	……	……	15.50	……	1.22	**15.00*	……	……
A 832	Nu-Life Fertilizer	……	……	……	……	……	12.00	……	1.74	**15.00*	……	……
A 883	Nu-Life Fertilizer	……	……	……	……	……	16.10	14.24	1.76	**15.00*	……	……
	Natural Guano Company, Aurora, Ill.											
A 487	Sheep's Head Brand	0.45	0.57	1.38	2.40	*2.25*	1.90	0.20	1.70	*1.00*	2.12	*1.50*
	Nitrate Agencies Company, Columbus, Ohio.											
	Acid Phosphate 16%	……	……	……	……	……	……	……	……	*16.00*	……	……
	Nitrate of Soda	……	……	……	……	*15.00*	……	……	……	……	……	……
	The Packer's Fertilizer Co., Sandusky, Ohio.											
121626	Acid Phosphate	……	……	……	……	……	18.60	1.62	16.98	*16.00*	……	……
101627	Acidulated Phosphate	……	……	……	……	……	15.65	1.20	14.45	*14.00*	……	……
A 441	Ammoniated Phosphate	0.54	0.18	0.25	0.97	*0.82*	11.45	1.94	9.51	*9.00*	0.98	*1.00*
A 535	Ammoniated Phosphate	0.49	0.13	0.28	0.90	*0.82*	11.45	1.64	9.81	*9.00*	1.08	*1.00*
A 869	Ammoniated Phosphate	0.40	0.18	0.26	0.84	*0.82*	11.70	1.76	9.94	*9.00*	0.95	*1.00*
A 947	Ammoniated Phosphate	0.20	0.22	0.28	0.70	*0.82*	11.93	3.09	8.84	*9.00*	1.20	*1.00*

A	442	Big Bonanza	1.11	0.43	0.13	1.67	1.65	14.25	2.12	12.13	12.00	....	....
	101628	Bone Meal	0.53	1.58	0.54	2.65	2.50	26.85	....	....	*20.00	....	....
A	297	O. K. Fertilizer	0.23	0.19	0.37	0.79	0.82	9.10	1.74	7 36	7.00	0.94	1.00
A	440	O. K. Fertilizer	0.12	0.20	0.48	0.80	0.82	9.45	1.86	7.59	7.00	1.00	1.00
A	804	O. K. Fertilizer	0.26	0.2	0.31	0.83	0.82	8.65	1.32	7.33	7.00	0.95	1.00
A	315	Phosphate with Humus	0.22	0.16	0.07	0.45	0.41	14.65	1.60	13.05	12.00	....	....
	101629	Potato, Tobacco and Truck Manure	0.58	0.66	0.50	1.74	1.65	9.95	2.30	7.65	8.00	1.05	1.00
A	806	Pure Bone with Phosphate and Potash	0.34	0.76	0.53	1.63	1.65	18.40	10.67	7.73	8.00	0.92	1.00
A	805	Sweepstakes	0.43	0.40	0.37	1.20	1.25	10.85	1.70	9.15	9.00	1.03	1.00
A	902	Sweepstakes	0.40	0.39	0.43	1.22	1.25	12.05	1.96	10.09	9.00	1.13	1.00
		The Pulverized Manure Co., Chicago, Ill.											
	101630	Wizard Brand Cattle Manure	0.33	0.43	1.24	2.00	1.80	1.40	0.38	1.02	1.00	1.57	1.00
A	408	Wizard Brand Sheep Manure	0.33	0.42	1.09	1.84	1.80	1.35	0.16	1.19	1.00	1.44	1.00
A	522	Wizard Brand Sheep Manure	0.42	0.39	1.16	1.97	1.80	1.80	0.18	1.62	1.00	3.28	1.00
		The Queen City Fertilizer Co., Sandusky, Ohio.											
	101631	Special Sugar Beet Grower	0.37	0.23	0.42	1.02	0.82	10.40	2.04	8.36	8.00	1.01	1.00
		Rasin-Monumental Co., Cincinnati, Ohio.											
	101632	Ammoniated Phosphate	1.06	0.37	0.24	1.67	1.60	8.45	1.12	7.33	7.00	1.29	1.00
	101633	Bone Meal Mixture Phosphate & Potash	0.42	0.42	0.28	1.12	0.80	22.70	11.92	10.78	9.00	1.04	1.00
A	942	Circle Brand Phosphate	....	....	....	....	....	13.85	2.88	10.97	10.00	0 96	1.00
	101634	Corn or Grain Food	1.60	0.64	0.37	2.61	2.40	12.85	1.44	11.41	9.00	....	....
A	808	Farmers Success	0.36	0.22	0.15	0.73	0.80	11.10	1.54	9.56	8.00	0.93	1.00
A	894	Farmers Success	0.52	0.26	0.23	1.01	0.80	11.65	1.94	9.71	8.00	1.01	1.00
	101635	Grain Fertilizer	0.48	0.31	0.11	0.90	0.80	15.15	0.80	14.35	13.00	....	....
	101636	High Grade Fertilizer	1.28	0.48	0.32	2.08	2.40	12.38	1.72	10.66	11.00	1.37	1.00
A	335	Reliable Fertilizer	0.45	0.20	0.09	0.74	0.80	14.80	1.42	13.36	11.00	1.00	1.00
A	568	Reliable Wheat and Corn Fertilizer	0.19	0.28	0.33	0.80	0.80	11.50	2.16	9.34	8.00	2.26	2.00
A	893	Royal Grain Grower	....	....	....	....	....	14.90	3.00	11.90	12.00	1.87	2.00
A	943	Royal Grain Grower	....	....	....	....	....	15.70	2.68	13.02	12.00	2.05	2.00
	121627	Special Manure	1.18	0.39	0.27	1.84	1.60	11.20	1.64	9.56	9.00	1.36	1.00
A	809	Special Plant Food	0.81	0.47	0.32	1.60	1.60	12.40	1.22	11.18	11.00	....	....
A	336	Straight Acid Phosphate	....	....	....	....	....	18.65	0.60	18.05	15.00	....	....
A	569	Straight Acid Phosphate	....	....	....	....	....	19.80	3.95	15.85	15.00	....	....
A	337	Tip Top Acid Phosphate	....	....	....	....	....	19.75	0.50	19.25	17.00	....	....
	101638	Vegetable and Potato Phosphate	1.44	0.49	0.33	2.26	2.00	10.10	1.14	8.96	8.00	1.34	1.00
	101639	Western Guano	0.21	0.09	0.21	0.51	0.40	15.25	0.76	14.49	13.00	1.13	1.00
	101640	Wheat and Oats Phosphate	1.31	0.22	0.13	1.66	1.60	13.20	0.76	12.44	11.00	1.45	1.00

*Total Phosphoric Acid.

ANALYSES OF COMMERCIAL FERTILIZERS FOR 1916, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory number.	Manufacturer and Trade Name.	Nitrogen.					Phosphoric Acid.				Potash.	
		As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total found.	*Total guaranteed.*	Total found.	Insoluble.	Available found.	*Available guaranteed.*	Total found.	*Total guaranteed.*
	F. S. Royster Guano Co., Baltimore, Md.											
A 874	4% Acid Phosphate						18.75	1.72	17.03	*14.00*		
A 238	H. G. 16% Acid Phosphate						18.63	0.76	17.87	*16.00*		
A 449	H. G. 16% Acid Phosphate						19.00	0.64	18.36	*16.00*		
A 931	Cloverdale Grain & Grass Grower						14.10	2.26	11.84	*10.00*	**1.79**	*2.00*
A 236	Cuckoo Crop Grower	0.41	0.31	0.21	0.93	*0.82*	9.85	1.84	8.01	*8.00*	0.90	*1.00*
A 260	Cuckoo Crop Grower	0.59	0.25	0.23	1.07	*0.82*	9.85	1.14	8.71	*8.00*	1.08	*1.00*
A 431	Cuckoo Crop Grower	0.53	0.26	0.19	0.98	*0.82*	10.15	1.28	8.87	*8.00*	0.98	*1.00*
A 219	Curfew Ammoniated Superphosphate	1.64	1.34	0.43	3.41	*3.29*	10.95	2.10	8.85	*8.00*		
	Dreadnought Fertilizer					*1.65*				*8.00*		*2.00*
	Drillwell Phosphate					*2.47*				*8.00*		*1.00*
A 584	Harmony Compound						13.90	1.66	12.24	*12.00*	**1.66**	*2.00*
A 589	Harmony Compound						15.55	2.56	12.99	*12.00*	1.93	*2.00*
A 261	Innovation Ammoniated Superphosphate	1.29	0.68	0.36	**2.33**	*2.47*	8.85	1.68	**7.17**	*8.00*		
A 504	Innovation Ammoniated Superphosphate	1.58	0.88	0.40	2.86	*2.47*	9.75	1.83	7.92	*8.00*		
A 451	Logical Compound	0.78	0.45	0.54	1.77	*1.65*	9.40	1.20	8.20	*8.00*	1.18	*1.00*
A 531	Logical Compound	0.96	0.47	0.52	1.95	*1.65*	9.48	1.94	**7.54**	*8.00*	1.00	*1.00*
101643	Nitrate of Soda				15.94	*15.00*						
A 259	Penguin Ammoniated Superphosphate	1.18	0.35	0.23	1.76	*1.65*	11.85	0.58	11.27	*10.00*		
A 432	Penguin Ammoniated Superphosphate	0.87	0.46	0.27	1.60	*1.65*	12.70	1.56	11.14	*10.00*		
A 452	Penguin Ammoniated Superphosphate	1.09	0.33	0.18	1.60	*1.65*	12.05	1.56	10.49	*10.00*		
A 218	Royal Blue Ammoniated Superphosphate	0.48	0.23	0.14	0.85	*0.82*	11.73	0.88	10.85	*10.00*		
A 258	Royal Blue Ammoniated Superphosphate	0.59	0.23	0.08	0.80	*0.82*	11.40	0.54	10.86	*10.00*		
A 972	Special Fish Guano	0.50	0.16	0.21	0.87	*0.82*	14.10	2.12	11.98	*11.00*	1.81	*2.00*
A 581	Special Wheat Grower	0.55	0.26	0.21	1.02	*0.82*	14.15	0.78	13.37	*12.00*		
A 963	Wheat, Oats & Barley Fertilizer	0.55	0.28	0.15	0.98	*0.82*	10.00	1.50	8.50	*8.00*	1.82	*2.00*
A 934	Wonder Worker Guano	0.48	0.21	0.19	0.88	*0.82*	10.65	1.60	9.05	*8.00*	**2.60**	*3.00*

		The Smith Agricultural Chemical Co., Columbus, Ohio.										
A	515	10% Acid Phosphate	....	....	....	....	....	11.45	1.40	10.05	10.00	....	....
A	288	14% Acid Phosphate	....	....	....	....	....	16.20	1.28	14.92	14.00	....	....
A	266	16% Acid Phosphate	....	....	....	....	....	18.75	1.06	17.69	16.00	....	....
A	226	Ammoniated Phosphate & Potash	0.20	0.17	0.48	0.85	0.82	11.00	1.20	9.80	9.00	1.07	1.00
A	249	Ammoniated Phosphate & Potash	0.37	0.19	0.37	0.93	0.82	10.70	1.34	9.36	9.00	1.10	1.00
A	287	Ammoniated Phosphate & Potash	0.45	0.20	0.39	1.04	0.82	11.05	1.60	9.45	9.00	0.96	1.00
A	419	Ammoniated Phosphate & Potash	0.39	0.14	0.37	0.80	0.82	10.85	1.40	9.45	9.00	1.20	1.00
A	250	Corn, Oats & Wheat Fertilizer	0.73	0.34	0.60	1.67	1.64	10.10	2.06	8.04	8.00	1.01	1.00
A	264	Corn, Oats & Wheat Fertilizer	0.77	0.29	0.49	1.55	1.64	10.75	1.54	9.21	8.00	1.20	1.00
A	421	Corn, Oats & Wheat Fertilizer	0.86	0.22	0.63	1.71	1.64	10.00	2.08	7.92	8.00	1.98	1.00
A	220	Crop Producer	0.88	0.30	0.43	1.61	1.64	12.93	1.26	11.67	10.00	....	....
A	420	Crop Producer	0.79	0.28	0.61	1.68	1.64	12.75	1.36	11.39	10.00	....	....
A	221	General Crop Fertilizer	0.26	0.20	0.47	0.93	0.82	9.20	1.60	7.60	7.00	1.36	1.00
A	265	General Crop Fertilizer	0.21	0.19	0.40	0.80	0.82	7.85	1.39	6.46	7.00	1.07	1.00
A	348	General Crop Fertilizer	0.24	0.19	0.37	0.80	0.82	9.20	1.24	7.96	7.00	1.12	1.00
A	514	General Crop Fertilizer	0.35	0.19	0.37	0.91	0.82	8.75	1.50	7.25	7.00	1.22	1.00
A	816	Grain Grower	0.60	0.14	0.14	0.88	0.82	16.75	1.54	15.21	15.00	1.22	1.00
A	251	Vegetable Grower	1.58	0.40	0.43	2.41	2.46	9.33	1.08	8.25	8.00	1.25	1.00
A	817	Vegetable Grower	1.61	0.40	0.55	2.56	2.46	9.80	1.20	8.60	8.00	0.96	1.00
A	368	Wheat Maker & Seeding Down	0.35	0.22	0.51	1.08	0.82	12.15	1.10	11.05	10.00	....	....
		Speidel & Swartz, Grand Haven, Mich.											
A	517	Celery Hustler	0.90	3.76	2.04	6.70	6.00	4.55	2.20	2.35	3.89	0.35	0.12
		The J. L. & H. Stadler Rendering & Fertilizer Co. Cleveland, Ohio.											
A	318	Acid Phosphate	....	....	....	....	....	17.45	0.30	17.15	14.00	....	....
A	835	16% Acid Phosphate	....	....	....	....	....	16.95	0.18	16.77	16.00	....	....
A	317	Ammoniated Acid Phosphate	0.58	0.08	0.18	0.84	0.40	15.50	1.26	14.24	12.00	....	....
A	356	Ammoniated Acid Phosphate	0.24	0.12	0.23	0.59	0.40	14.15	1.12	13.03	12.00	....	....
A	275	Ammoniated Phosphate and Potash	0.30	0.11	0.25	0.66	0.40	15.05	0.92	14.13	13.00	1.04	1.00
	101644	General Crop Grower	1.00	0.32	0.55	1.87	1.60	13.05	2.64	10.41	10.00	1.11	1.00
A	326	Grain Grower	1.01	0.32	0.65	1.98	1.60	10.50	1.46	9.04	8.00	2.24	2.00
A	316	Harvest King	0.45	0.21	0.43	1.09	0.80	11.35	1.52	9.83	9.00	1.05	1.00
A	358	Harvest King	0.38	0.28	0.42	1.08	0.80	11.65	1.58	10.07	9.00	1.06	1.00
A	810	Harvest King	0.52	0.27	0.53	1.32	0.80	10.95	1.46	9.49	9.00	1.22	1.00
	101645	Pure Bone Meal	0.69	1.54	0.97	3.20	2.80	22.20	....	....	*20.00	....	....
A	907	Sugar Beet Special	0.50	0.35	0.50	1.35	0.80	10.25	1.48	8.77	8.00	2.24	2.00

*Total Phosphoric Acid.

ANALYSES OF COMMERCIAL FERTILIZERS FOR 1916, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory number.	Manufacturer and Trade Name.	Nitrogen.					Phosphoric Acid.				Potash.	
		As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total found.	*Total guaranteed.*	Total found.	Insoluble.	Available found.	*Available guaranteed.*	Total found.	*Total guaranteed.*
	The J. L. & H. Stadler Rendering & Fertilizer Co.—Con.											
101646	Valley Phosphate	0.90	0.41	0.74	2.05	*2.00*	12.05	2.82	9.23	*9.23*	1.49	*1.50*
A 357	Vegetable & Grain Grower	0.25	0.25	0.41	0.91	*0.80*	12.06	1.95	10.06	*10.00*	0.53	*0.50*
A 834	Vegetable & Grain Grower	0.27	0.27	0.41	0.95	*0.80*	12.95	2.00	10.95	*10.00*	0.56	*0.50*
101647	Vegetable Manure	0.88	0.36	0.52	1.76	*1.60*	13.90	2.82	**11.08**	*12.00*	....	....
A 923	1-8-2	0.54	0.34	0.74	1.62	*0.80*	10.80	4.74	**6 06**	*8.00*	2.01	*2.00*
A 978	1-8-2	0.62	0.31	0.68	1.61	*0.80*	10.35	3.30	**7.05**	*8.00*	1.80	*2.00*
	G. B. Stock Xylite Grease & Oil Co., Port Huron, Mich.											
	Xylite	....	....	....	....	*5.00*	....	....	....	*7.25*	....	....
	Swift & Company, Chicago, Ill.											
A 605	Ammoniated Bone Phosphate & Potash	0.65	0.43	0.59	1.67	*1.65*	12.30	1.60	10.70	*10.00*	0.65	*0.50*
A 243	Bean & Grain Grower	0.43	0.22	0.45	1.10	*0.82*	10.80	1.45	9.35	*8.00*	**2.74**	*3.00*
A 340	Bean & Grain Grower	0.48	0.15	0.48	1.11	*0.82*	10.30	1.68	8.62	*8.00*	3.14	*3.00*
A 819	Bean & Grain Grower	0.26	0.19	0.30	0.75	*0.82*	10.30	1.20	9.10	*8.00*	**2.05**	*3.00*
A 460	Bean & Sugar Beet Grower	0.33	0.23	0.37	0.93	*0.82*	14.05	1.32	12.73	*12.00*	0.97	*1.00*
A 860	Bean & Sugar Beet Grower	0.30	0.26	0.31	0.87	*0.82*	14.45	1.38	13.07	*12.00*	**0.76**	*1.00*
A 873	Bean & Sugar Beet Grower	0.37	0.30	0.30	0.97	*0.82*	14.75	1.40	13.35	*12.00*	0.92	*1.00*
A 878	Bean & Sugar Beet Grower	0.30	0.17	0.31	0.78	*0.82*	14.50	1.48	13.02	*12.00*	1.31	*1.00*
A 886	Champion Wheat & Corn Grower	0.30	0.45	0.53	**1.28**	*1.65*	13 65	1.54	12.11	*12.00*	2.01	*2.00*
A 917	Champion Wheat & Corn Grower	0.75	0.51	0.59	1.85	*1.65*	14.60	1.91	12.69	*12.00*	**1.72**	*2.00*
A 414	Clay Soil Special	0.60	0.35	0.65	1.60	*1.65*	14.20	1.28	12.92	*12.00*	....	....
A 429	Clay Soil Special	0.79	0.42	0.57	1.78	*1.65*	13.60	1.56	12.04	*12.00*	....	....
A 812	Clay Soil Special	0.85	0.31	0.51	1.67	*1.65*	14.55	2.10	12.45	*12.00*	....	....
A 223	Complete Fertilizer	0.22	0.18	0.37	0.77	*0.82*	8.85	1.10	**7.75**	*8.00*	0.97	*1.00*
A 242	Complete Fertilizer	0.27	0.21	0.29	0.77	*0.82*	9.15	1.18	**7.97**	*8.00*	0.92	*1.00*

A	267	Complete Fertilizer	0.28	0.20	0.32	0.80	*0.82*	9.65	1.12	8.53	*8.00*	0.95	*1.00*
A	325	Complete Fertilizer	0.36	0.21	0.31	0.88	*0.82*	9.74	1.23	8.51	*8.00*	1.03	*1.00*
A	339	Complete Fertilizer	0.29	0.11	0.38	0.78	*0.82*	9.50	1.32	8.18	*8.00*	0.94	*1.00*
A	361	Complete Fertilizer	0.22	0.21	0.33	0.76	*0.82*	8.63	1.26	**7.37**	*8.00*	0.88	*1.00*
A	572	Diamond I Grain Grower	0.24	0.19	0.37	0.80	*0.82*	12.05	1.54	10.51	*10.00*	2.00	*2.00*
A	904	Diamond I Grain Grower	0.32	0.11	0.31	0.74	*0.82*	12.35	2.16	10.19	*10.00*	2.00	*2.00*
A	919	Diamond I Grain Grower	0.33	0.19	0.38	0.90	*0.82*	12.15	1.34	10.81	*10.00*	2.11	*2.00*
A	461	Diamond K Grain Grower	0.34	0.23	0.36	0.93	*0.82*	14.15	1.34	12.81	*12.00*	0.92	*1.00*
A	482	Diamond K Grain Grower	0.38	0.18	0.31	0.87	*0.82*	14.05	1.36	12.69	*12.00*	**0.79**	*1.00*
A	499	Diamond K Grain Grower	0.34	0.21	0.35	0.90	*0.82*	14.40	1.50	12.90	*12.00*	1.00	*1.00*
A	977	Diamond M Grain Grower	0.83	0.30	0.52	1.65	*1.65*	14.55	3.16	11.39	*11.00*	1.18	*1.00*
		Diamond S Phosphate									*10.00*		
A	885	Dissolved Animal Bone	0.71	0.46	0.43	1.60	*1.65*	22.15	6.74	**15.41**	*16.00*		
A	459	Dissolved Animal Bone-Potash Mixture	0.55	0.55	0.42	1.52	*1.23*	21.70	3.70	18.00	*16.00*	1.06	*1.00*
A	481	Dissolved Animal Bone-Potash Mixture	0.65	0.48	0.43	1.56	*1.23*	21.47	4.00	17.47	*16.00*	0.81	*1.00*
A	513	Dissolved Animal Bone-Potash Mixture	0.67	0.24	0.68	1.59	*1.23*	21.95	3.44	18.51	*16.00*	0.98	*1.00*
A	268	Garden City Phosphate						15.55	0.68	14.87	*14.00*		
A	289	Garden City Phosphate						15.05	0.90	14.15	*14.00*		
A	399	Garden City Phosphate						15.70	0.80	14.90	*14.00*		
A	430	High Grade Acid Phosphate						19.15	1.04	18.11	*16.00*		
A	472	High Grade Acid Phosphate						18.10	1.54	16.56	*16.00*		
A	435	Lawn Fertilizer 3-8-½	1.20	0.50	0.60	**2.30**	*2.47*	9.75	1.54	8.21	*8.00*	0.86	*0.50*
A	398	Michigan Special 2-8-5	0.77	0.30	0.45	**1.52**	*1.65*	9.55	1.28	8.27	8.00	*5.12*	*5.00*
		Nitrate of Soda					*14.81*						
A	416	Pulverized Sheep Manure	0.70	0.68	1.81	3.19	*2.06*	3.00	0.46	2.54	**1.50*	**1.35**	*2.00*
A	434	Pulverized Sheep Manure	0.51	0.39	1.06	1.96	*2.06*	2.65	0.42	2.23	**1.50*	2.32	*2.00*
A	507	Pulverized Sheep Manure	0.12	0.44	1.36	**1.92**	*2.06*	**1.08**			**1.50*	2.05	*2.00*
A	826	Pulverized Sheep Manure	0.17	0.45	1.38	2.00	*2.06*	1.78			**1.50*	*2.48*	*2.00*
A	862	Pulverized Sheep Manure	0.19	0.71	0.61	**1.51**	*2.06*	1.65			**1.50*	2.22	*2.00*
A	428	Pure Bone Meal	0.24	1.38	0.92	2.54	*2.47*	24.25			**24.00*		
A	433	Pure Bone Meal	0.04	1.59	0.93	2.56	*2.47*	23.90			**24.00*		
A	825	Pure Bone Meal	0.20	1.26	1.00	2.46	*2.47*	24 20			**24.00*		
A	222	Special Superphosphate	0.65	0.31	0.51	**1.47**	*1.65*	10.60	1.74	8.86	*8.00*	1.04	*1.00*
A	338	Special Superphosphate	0.80	0.31	0.54	1.65	*1.65*	9.80	1.68	8.12	*8.00*	1.03	*1.00*
A	427	Special Superphosphate	0.63	0.26	0.61	**1.50**	*1.65*	11.30	2.18	9.12	*8.00*	0.99	*1.00*
A	458	Special Superphosphate	0.74	0.29	0.51	**1.54**	*1.65*	9.75	1.58	8.17	*8.00*	1.00	*1.00*
A	604	Special Superphosphate	0.69	0.38	0.58	1.65	*1.65*	10.20	1.68	8.52	*8.00*	1.00	*1.00*

*Total Phosphoric Acid.

ANALYSES OF COMMERCIAL FERTILIZERS FOR 1916, EXPRESSED IN PARTS IN ONE HUNDRED.—Concluded.

Laboratory number.	Manufacturer and Trade Name.	Nitrogen.					Phosphoric Acid.				Potash.	
		As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total found.	*Total guaranteed.*	Total found.	Insoluble.	Available found.	*Available guaranteed.*	Total found.	*Total guaranteed.*
	Swift & Company.—Con.											
A 324	Sugar Beet Fertilizer	0.62	0.40	0.62	1.64	*1.65*	12.35	1.74	10.61	*10.00*	0.64	*0.50*
A 879	Sugar Beet Fertilizer	0.69	0.41	0.58	1.68	*1.65*	11.40	1.55	9.85	*10.00*	0.50	*0.50*
A 241	Superphosphate	0.51	0.33	0.72	1.56	*1.65*	10.30	1.72	8.58	*8.00*	2.08	*2.00*
A 838	Superphosphate	0.50	0.40	0.56	**1.46**	*1.65*	10.40	1.62	8.78	*8.00*	2.00	*2.00*
A 871	Superphosphate	0.51	0.47	0.59	1.57	*1.65*	9.95	1.46	8.49	*8.00*	2.00	*2.00*
A 415	Tankage & Bone Phosphate	0.38	0.21	0.31	0.90	*0.82*	13.60	0.96	12.64	*12.00*	....	....
A 897	Tankage & Bone Phosphate	0.30	0.38	0.30	0.98	*0.82*	15.25	1.78	13.47	*12.00*	....	....
101650	Tomato & Vegetable Grower	1.58	0.42	0.53	2.53	*2.47*	11.30	1.50	9.80	*8.00*	1.11	*0.50*
A 498	Truck Fertilizer	1.01	0.46	0.72	**2 19**	*2.47*	10.75	2.08	8.67	*8.00*	0.96	*1.00*
A 508	Truck Fertilizer	0.85	0.46	0.82	**2 13**	*2.47*	10.25	2.16	8.09	*8.00*	1.06	*1.00*
A 512	Truck Fertilizer	1.22	0.53	0.81	2.56	*2.47*	9.80	1.74	8.06	*8.00*	1.00	*1.00*
A 861	Truck Fertilizer	1.68	0.23	0.49	2.40	*2.47*	10.00	2.43	**7.57**	*8.00*	0.95	*1.00*
A 875	1-8-2 Fertilizer	0.39	0.19	0.23	0.81	*0.82*	10.48	1.34	9.14	*8.00*	**1.66**	*2.00*
	Pioneer Brands.											
A 918	Acidulated Bone and Potash	0.56	0.55	0.45	1.56	*1.23*	21.90	5.68	16.22	*16.00*	0.97	*1.00*
A 525	Bean and Sugar Beet Special 2-10-.5	0.77	0.33	0.37	**1.47**	*1.65*	11.85	1.14	10.71	*10.00*	0.50	*0.50*
A 393	No. 4 Grain Grower 1-8-1	0.32	0.21	0.26	0.79	*0.82*	9.25	1.42	7.83	*8.00*	1.02	*1.00*
A 916	No. 4 Grain Grower 1-8-1	0.23	0.17	0.37	0.77	*0.82*	10.25	1.64	9.61	*8.00*	1.44	*1.00*
A 524	No. 5 Grain Grower 2-12-0	0.81	0.38	0.42	1.61	*1.65*	14.68	1.30	13.38	*12.00*	....	....
A 523	Special General Crop Grower 2-8-1	0.56	0.42	0.49	**1.47**	*1.65*	9.87	1.80	8.07	*8.00*	0.94	*1.00*
121630	Tankage and Bone Phosphate	0.59	0.30	0.33	1.22	*0.82*	15.85	1.82	14.03	*12.00*	....	....
	Tuscarora Fertilizer Co., Chicago, Ill.											
A 851	Acid Phosphate	....	....	....	....	....	14.70	0.28	14.42	*14.00*	....	....
101653	Phosphate & Potash Special	....	....	....	....	....	10.85	0.32	10.53	*10.00*	0.86	*1.00*
A 857	Special Corn, Wheat & Bean Fertilizer	0.45	0.25	0.21	0.91	*0.82*	*9.08*	1.14	7.94	*8.00*	0.84	*1.00*
A 859	Tankage & Phosphate	0.85	0.48	0.34	1.67	*1.65*	12.20	1.88	10.32	*10.00*	....	....
101654	Wheat, Corn & Bean Grower	0.44	0.18	0.46	1.08	*0.82*	10.35	0.96	9.39	*8.00*	2.14	*2.00*

		Virginia-Carolina Chemical Co. (of Delaware) Cincinnati, Ohio.											
	101655	V-C 16% Acid Phosphate	......	......	......	......	......	20.40	1.24	19.16	*16.00*	......	......
A	582	V-C Champion Corn & Wheat Grower	0.67	0.17	0.30	1.14	*0.80*	10.35	2.28	8.07	*8.00*	2.61	*2.00*
	101656	V-C Complete Manure	1.17	0.47	0.32	1.96	*0.80*	11.40	1.64	9.76	*8.00*	1.91	*1.00*
A	583	V-C Prolific Grain Grower	......	......	......	......	......	14.65	3.75	10.90	*12.00*	1.84	*2.00*
A	945	V-C Star Fertilizer	0.90	0.43	0.40	1.73	*1.60*	8.85	1.28	7.57	*7.00*	1.15	*1.00*
		V-C Wheat Compound	......	......	......	......	*0.80*	......	......	......	*11.00*	......	*1.00*
		The Wuichet Fertilizer Co., Dayton, Ohio.											
A	536	Ammonia Special	0.64	0.58	0.78	2.00	*1.60*	15.75	4.46	11.29	*10.00*	......	......
A	864	Ammonia Special	0.61	0.65	0.54	1.80	*1.60*	15.55	4.28	11.27	*10.00*	......	......
		"E" Raw Bone & Phosphate	......	......	......	......	*1.60*	......	......	......	*8.00*	......	*0.50*
A	528	"E" Ruby	0.22	0.34	0.69	1.25	*1.00*	13.25	3.40	9.85	*9.00*	0.50	*0.50*
A	529	"E" Ruby	0 20	0.33	0.71	1.24	*1.00*	14.45	2.64	11.81	*9.00*	0.31	*0.50*
A	538	"E" Ruby	0.19	0.27	0.50	0.96	*1.00*	14.90	2.08	12.82	*9.00*	0.37	*0.50*
A	867	"E" Ruby	0.33	0.43	0.64	1.40	*1.00*	13.85	3.28	10.57	*9.00*	0 26	*0.50*
A	457	"E" Spot Cash	1.26	0.28	0.07	1.61	*1.60*	13.75	5.48	8.27	*8.00*	1.05	*1.00*
A	527	"E" Spot Cash	0.49	0.54	0.56	1.59	*1.60*	12.25	3.36	8.89	*8.00*	0.97	*1.00*
A	539	"E" Spot Cash	0.58	0.45	0.57	1.60	*1.60*	13.55	3.98	9.57	*8.00*	1.00	*1.00*
A	868	"E" Spot Cash	0.50	0.63	0.57	1.70	*1.60*	14.05	4.88	9.17	*8.00*	0 91	*1.00*
	101659	16% Phosphate	......	......	......	......	......	23.00	5.12	17.88	*16.00*	......	......
		Superior Pure Raw Bone	......	......	......	......	*3.20*	......	......	......	**20.00*	......	......

*Total Phosphoric Acid.

YELLOW ROCKET.

Special Bulletin No. 8[illegible].

A Dangerous Weed.

BY ERNST A. BESSEY, PROFESSOR OF BOTANY.

In the past few years the plant known commonly as Yellow Rocket, Winter Cress, Herb Barbara, etc., (*Barbarea barbarea* (L.) MacM.), has assumed a conspicuous place among the serious weed pests of the State of Michigan. The plant is a native of Europe whence it reached America in various ways, chiefly, in all probability, by the contamination of grass and clover seeds with its seeds. It is largely in this manner that it has been introduced into Michigan and spread from locality to locality.

The seeds are produced in Michigan late in May and throughout June. They germinate quickly the same summer and form a low stemless plant with long tap-root and a cluster of shining green leaves. These leaves are very characteristic in that they are lobed, with a large, round terminal lobe and a couple of pairs or so of small lateral lobes. They are free from all hairiness. No upright stem is formed the first season, but as the plant increases in size the crown becomes divided and the roots become greatly branched, losing the tap-root nature. The leaves often remain green throughout the winter if there is a good covering of snow, being uncovered by the European peasants and collected for use as greens on St. Barbara's day, December 4th. When not protected by the snow some, if not all, of the leaves are killed during the winter, but the root remains alive.

In April, new leaves are produced and soon several to many (5 to 20 or so) upright leafy stems shoot up, reaching a height of 1½ to 2 feet. Each stem may branch considerably, each branch and branchlet being terminated by a cluster of yellow flowers. These are at first crowded closely but as they set seed the branch lengthens so that the slightly four-angled, slender, inch-long pods are scattered along the stems at intervals of ½ to 1 inch. Each pod produces 10 to 20, mostly about 15 seeds. The latter are about the size of clover or timothy seeds. The number of flowers and seeds produced by a single plant is enormous. One well-developed plant, by no means the largest size, possessed over 14,000 flowers, which at 15 seeds to a pod means over 200,000 seeds to the plant.

The seeds begin to ripen about the end of May and continue to be produced for about a month, after which the plant dies down. In many cases the roots die, too, but in some cases remain alive and produce tufts of leaves and then in the following April send up new up-

right stalks again which produce another crop of seeds. Just how long the same plant will remain alive has not been determined.

Yellow Rocket resembles wild mustard quite markedly, which is not to be wondered at, as it belongs to the same family. Its flowers are not distinguishable from those of the mustard except that they are smaller. Mustard does not have so many upright stems, usually having one main stem, branching freely; it is also much later as it is an annual and does not have the benefit of a start the previous season. The root of mustard retains its tap-root nature to a large extent while that of Yellow Rocket in its second season is greatly divided and branched. It is also usually more or less hairy while Yellow Rocket is free from hairs. The leaves of mustard do not have so large or rounded a terminal lobe and so small lateral lobes as do those of Yellow Rocket.

As it lacks long underground running roots or stems like Canada thistle, milkweed, etc., yellow rocket need never be feared on land that is under cultivation constantly or at rather frequent intervals. Its chief harm is in meadows, pastures, etc.; i. e. where the land is left two or three years without cultivation. Thus in fields of alfalfa it is a serious pest, as it multiplies from year to year with the greatest rapidity. So also a grain field in which a few plants occur will be thoroughly seeded to yellow rocket before the grain is harvested. The clover the remainder of that year will show only the low tufts of leaves of the weed but the next spring the field may appear yellow, so numerous are the plants. This of course, greatly reduces the value of the field, both because of the direct injury to the clover crop due to the loss of plant food and water and because of the inferior hay that results from the presence of the yellow rocket.

The smooth shining epidermis makes spraying with any of the milder herbicides useless,—and the location of the weed in meadows, clover fields, etc., makes it impossible to spray with poisonous sprays which would be injurious to animals feeding upon hay from that field.

Spudding out the plants before they go to seed is the most practical method of fighting this weed, provided it is not too abundant. In the latter case the field should be plowed. In any case this ought to be done before the end of May as seed production begins about the first of June (or earlier or later, depending upon the season). Careless plowing without subsequent harrowing or cultivation will not always destroy all of the first year plants and these will manage to regain their foothold and grow until fall, producing the seeding plants next year.

Mowing, although destroying the tops of the plants, and accordingly thousands of flowers, is not to be recommended as very short branches are then formed near the root and these produce flowers and seeds below the reach of the mowing machine and fill the ground with seed to make more trouble next year.

SUMMARY.

Yellow rocket, a native of Europe, is one of the mustard family and a very serious weed.

It is a biennial or perennial and does not blossom and seed until the second season, being inconspicuous the first year.

It is introduced as an impurity in seed of clover, grasses, etc.

A well developed plant may produce 200,000 seeds in one season.

Mowing will not control the pest.

A short rotation with at least two seasons in hoed or cultivated crops will keep the number down.

The best practice is to spud out every plant the first season they appear and every year thereafter, not allowing them to produce seed.

If very abundant, plow under before they seed and spud out every plant that appears in succeeding years.

CONCISE DIRECTIONS FOR CONTROL.

Special Bulletin No. 81.

BY G. H. COONS AND EZRA LEVIN.

It is definitely known that *seedlings commonly carry the infection to the field.* The seed is not thought to carry the fungous spores. Therefore, if the soil in the flats or cold frame is clean the plants start clean.*

The disease is brought to the field on the seedlings.

To insure clean seedlings *spray the young plants at least twice* with weak Bordeaux mixture (2-2-50).

Spray young plants.

Do not follow tomatoes with tomatoes. *Have a systematic rotation for your fields.* Cleaning up of trash in garden patches and fields is a good sanitary measure. Do not throw old vines on the manure pile or compost heap.

The disease is known to live over from year to year in old diseased plants.

Where the type of culture permits, *staking* of tomatoes will largely prevent damage from tomato leaf-spot. Staked tomatoes give greater yields, earlier crops and allow most efficient spraying.

The spores splash from the soil and from the lower leaves.

After the plants are well started in the field, spray every 10 days with Bordeaux mixture 4-4-50, made exactly according to directions. The early sprayings are most important in preventing the disease from getting a foothold. When the plants are large, unless the application is thorough it will pay to spray down and back on the same row. This, if a gentle wind is blowing and if the sprayer gives a good mist, will insure a thorough application.

Tomato leaves can be protected by Bordeaux mixture.

Tomato leaves make a quick growth. *Frequent sprayings are necessary* to keep the new growth covered.

Frequent sprayings are to keep the new growth covered.

*(1) Soil from fields which have not recently grown tomatoes is safe for use. Manure containing tomato trash is unsafe.
(2) Used soil may be sterilized by steaming by the inverted pan method.
(3) Used soil may be disinfected by drenching with formaldehyde 1 to 100 parts water. Use 1 gallon to the cubic foot, drenching the soil completely. A quart of solution will disinfect a flat. Cover with paper or canvas over night. Then turn the soil thoroughly to allow the fumes to escape. As soon as the soil is in good condition, plantings may be made. This treatment is simple, cheap and easy. It will also prevent damping off.

Fig. 2. Diseased plant showing the killing of the lower leaves.

INTRODUCTION*

Michigan is one of the great tomato-growing states. The crop produced amounts to nearly a million dollars annually. Tomatoes are grown for ordinary market purposes, for canning and for seed. The type of culture and the varieties used vary with the utilization of the crop. The methods used in growing the crop influence the prevalence of this disease to a great extent. For example, it is found that where tomatoes are staked, the damage from leaf-spot is greatly reduced. In general, seedlings are grown in greenhouses or cold frames and set by hand in the fields. This method of procedure lends itself readily to control measures which entirely prevent damage from the leaf-spot disease.

Michigan tomato crop is worth $1,000,000 annually.

THE IMPORTANCE OF THE LEAF-SPOT DISEASE.

The leaf-spot disease of tomato, commonly called by growers "blight," caused a practical failure of the crop in many localities in 1915, and for the preceding five years, has materially shortened each growing season. This condition is found in every state where tomatoes are grown commercially. The consensus of opinion of pathologists from all parts of the United States, is that the Septoria leaf-spot is the most serious disease of the tomato.

The leaf spot is the most serious disease of the tomato.

The disease has been found in the northern, as well as the southern parts of Michigan. Its distribution is probably as great as tomato culture.

The disease is as widespread as tomato culture.

HOW TO TELL THE DISEASE.

The signs of the leaf-spot disease are well expressed by the common name "blight." The growers notice a general unthriftiness in the plants along with a blight which begins on the lower leaves and which gradually advances upward on the plant. (Fig. 2.) Blighted leaves if carefully examined are seen to be covered with small circular spots, commonly less than 1/8 of an inch in diameter. In some cases a whole leaflet may be involved. These spots are sometimes black, but are usually grayish with a black border. (Frontispiece.) As the disease progresses the spots dry and the leaflets turn

Leaf spot shows up as a blighting of the leaves from the bottom upward.

*This popular bulletin is based on Technical Bulletin 25 of this Station. Anyone interested in the more detailed account may secure the technical bulletin so long as the supply lasts.
Those who make request, may be placed upon the mailing list to receive bulletins from the College.

Spots appear on the leaflets. Then the leaves die, falling from the plant at the least jar.

yellow. The leaves die and drop from the plant at the slightest jar. The disease advances up the plant, and soon all leaves, except a small tuft at the end fall from the stem. The dropping of the leaves exposes the fruit, which may sunburn badly.

Spots are also formed on the calyx and stem but rarely on the fruit.

The leaves manufacture sugar and starch. The leaf spot disease destroys the factories.

The damage to the crop comes largely from the loss of the leaf surface. The leaves of plants are the manufacturing organs which produce the starch and sugars which make up the greater part of the solid matter of the fruit. A leaf disease interferes with the manufacturing power, hence, the

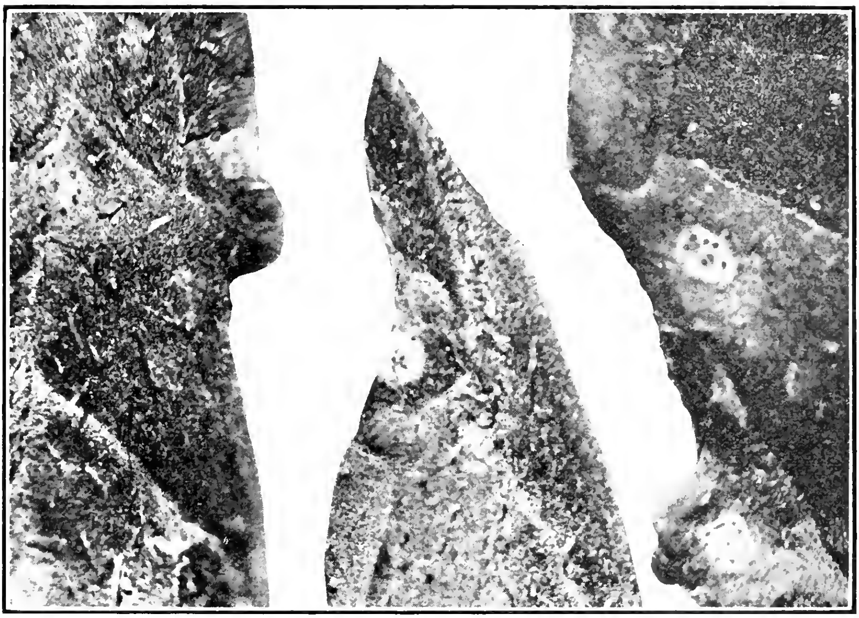


Fig. 3. Diseased spots magnified five times.

Small, sour, watery tomatoes are caused by leaf spot.

fruit grows slowly or not at all. Half-matured fruit fails to ripen. The crop from plants with blighted foliage is small, sour and watery. This last condition is often complained of by canners; although they ascribe "watery" tomatoes to a wet season, rather than to a fungous disease made severe by the season. In short, all the general signs are those which go with disturbance of food manufacture by the leaves.

THE CAUSE OF LEAF-SPOT.

A fungus steals from the tomato plant.

Leaf-spot of tomato is caused by a parasitic fungus called *Septoria lycopersici* which grows and feeds in the tomato leaf. A parasitic fungus is a microscopic plant which makes

no food for itself but which steals its living from another plant. If a diseased spot is examined with a microscope, the leaf tissue is found to be pierced by minute threads. These threads are the body of the fungous parasite. After the threads have grown in the leaf and occupied considerable area, small black dots appear on both the upper and lower surfaces. (Fig. 3.)

The small black dots are hollow spherical cases which contain countless long needle-shaped bodies called *spores.* (Fig. 4.) These spores are to the fungus what seeds are to the higher plants. A spore washed to a tomato leaf and given favorable temperature and moisture will sprout and enter the leaf, quite as a seed sprouts and grows, only the soil the fungus uses is the leaf tissue.

Needle-shaped spores are the "seeds" of this parasitic fungus.

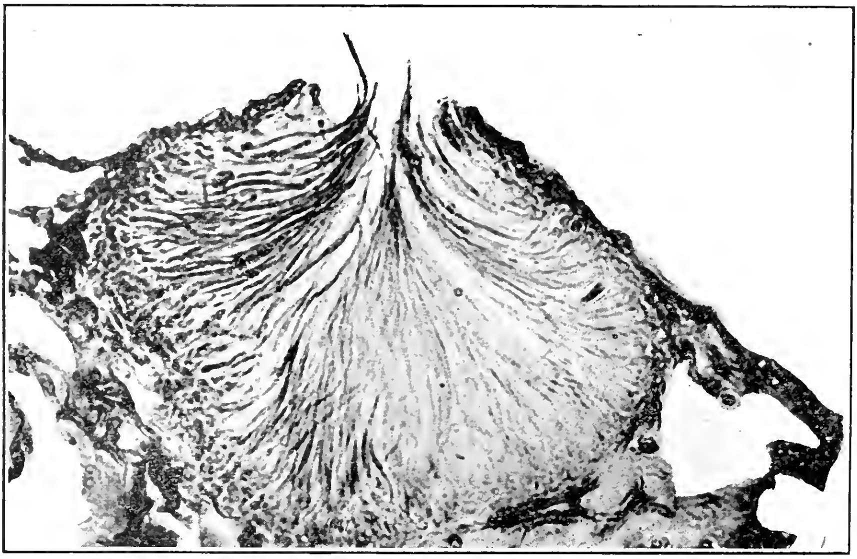


Fig. 4. Thin section of spore case, showing long needle-shaped spores. Magnified 800 times.

The spores of this fungus have a jelly-like coat and when a diseased leaf is wet, the spores swell and push out of the spore cases in sticky masses. When the spores are once outside the spore case they float apart in the water on the leaf and frequently sprout and enter, thus making the spot larger or causing new ones.

The spores float about on wet leaves, or,

The spores from a diseased leaf may be washed or splashed from leaf to leaf during rains, or if the plants are worked when wet, may be carried from plant to plant on the cultivator or on the clothes of the worker.

Rains splash the spores about.

The spores can endure at least three days drying, hence, those which wash to the ground may be dried on the dust and blown about, thus leading to a wider distribution of the disease in the field or from field to field.

Cultivating wet plants spreads the spores from plant to plant.

How the spore attacks the tomato leaf.

If a spore is put under proper conditions it will begin to sprout in about twenty-four hours. The sprouts are threads which push out from the needle-like spore. In a few hours after sprouting the thread-like tube enters the breathing pore of the leaf. Then the fungus grows in the tissues of the plant, twining among the cells. In about six days after the spore reaches the leaf, the first watery discoloration produced by the fungus can be seen. In less than ten days the spot is definite and the killing of the invaded leaf tissue is completed. The fungus fruits in about 13 days and produces several black spore cases. Hence, one spore gives rise to countless thousands of other spores, each capable of repeating this story.

In 13 days one spore produces thousands of similar spores.

Either the upper or lower surface may be the point of entry.

If the lower surface is the point of entry the spots are large and may involve one-half or the whole of a leaflet. If the upper surface is the point of entry the spots may be no larger than the head of a pin. Usually the upper leaves show this latter type of infection, evidently from dust as a source. The lower leaves are infected from beneath, doubtless by splashings from the ground or from the older leaves.

The fungus lives over on old trash from last year's diseased plants.

The fungus lives over winter on the trash from a preceding tomato crop. It lives over in the greenhouses or cold frame in the trash from seedlings left in the soil. The spores have not been found on tomato seed. Hundreds of plants from all the common varieties have been grown in clean soil without one case of leaf-spot appearing spontaneously.

The weather does not cause the leaf spot disease.

The spores of the fungus are released from the spore case only when the leaf is wet. Heavy dews give conditions which allow an oozing of spores. By far the greatest factor in spreading the fungus is a washing, splashing rain. Therefore, the disease is most serious in a rainy season such as that of 1915. Many growers make the mistake in thinking that the tomato disease is caused by the weather, while the truth is that the disease is caused by a parasite whose spread is favored by the wet conditions.

Growers must adopt measures which will insure a crop in spite of the weather.

HOW TO PREVENT LOSS FROM TOMATO LEAF-SPOT.

Resistant Varieties.

No resistant variety is as yet found.

In an experiment with more than 50 of the leading tomato varieties, no variety was found strikingly resistant or susceptible. Many varieties are vigorous growers and continually keep ahead of the leaf-spot by the production of new foliage. Dwarf varieties usually suffer more damage than the ordinary sorts.

Before other control measures can be considered, we must recognize the following observations that have been dealt with above:

Summary of facts about the disease.

1. The sources of infection are at least two: the greenhouse or the hotbed and the diseased trash in the field.
2. Infection results from inoculation upon the upper and lower surfaces of the leaf.
3. The period from the time of inoculation to spore exudation is about 13 days.
4. Moisture is the primary agent in dissemination of the disease.
5. The exudate of spores is in the form of a mucilaginous mass. The spores are always transferred by some external agency.
6. It has been shown that the fungus will not grow at 85° F. and will not revive after 5 days at 98° F. Since such temperatures are frequently reached during the summer months, the heat relation must be taken into consideration as a natural means of checking the disease.

Prevention methods necessary.

The most important control measures for this disease are preventive. Clean seedlings in clean soil, if reasonably isolated remain practically free from the disease.

Clean soil.

In order to be sure that the seedlings do not become diseased at the start, clean soil should be used in the greenhouses devoted to seedling production. The soil should be fresh or sterilized. The seedlings should be sprayed as soon as their height above ground makes it practicable, and again before being transplanted to the field. For this a weak Bordeaux mixture (2-2-50) is advised.

Destroy old trash.

Since it has been determined that wintered-over, diseased vines possess spores which are viable, the old trash must be destroyed as far as possible. Since, however, this is not practical except in greenhouses and gardens, rotation is strongly urged. While there is no experimental evidence to demonstrate the value of rotation as a means of control, numerous instances have been noted in which rotation has been successful in controlling the disease.

The spores are carried when wet.

Since spores are released from the spore cases when wet the plants should not be "worked" until the plants are dry. Growers have reported cases where cultivation began at a small infected patch and the disease was carried over the entire field, and that in less than three weeks the entire field was spotted. This is now readily explained. In greenhouse practice, irrigation should replace the ordinary use of the hose.

Spray with Bordeaux.

After transplanting to the field, spray with 4-4-50 Bordeaux mixture every 10 days. As has been shown, the period from time of inoculation to spore exudation is at least 13 days. Allowing this leeway for differences in period of infection, it would seem that a spray so applied would give the necessary protection.

Reasons for failures in control.

The greatest part of and the strongest infection results from inoculation on the lower surface of the leaf. Therefore, all the precautions are less effective if the plants are allowed to run at will over the ground. The spraying of the under side of the leaf is not accomplished unless the application is thorough. Failures to control the disease by spraying are doubtless due to lack of thoroughness and timeliness.

How to spray.

Spraying with 4-4-50 Bordeaux mixture in the fields where tomatoes are staked should be extremely successful. In this state spraying will not be most effective unless the spray reaches the lower surface of the leaves. A sprayer such as is used for potatoes, with two side nozzles set to shoot upward and if practical, with one central nozzle to spray downward for each row will, under high pressure, be most efficient in Michigan fields.

Spraying has succeeded in in Michigan.

Spraying tomatoes with Bordeaux is a common practice in many tomato-growing centers. Wherever it has been tried it has become a fixed part of the culture of the crop. No grower can afford to risk his crop, and no company can afford to risk its acreage. The spraying experiment of the College in 1913 at Plymouth is a good example of what may be accomplished. In this experiment "the plants that were sprayed with Bordeaux mixture four times, produced 12.5 tons per acre while the plants that were not sprayed produced 5.2 tons per acre. The first spraying was made about one month after the plants were set in the field and frequently enough afterward to protect the new growth." (Every ten days or two weeks).*

Copper sulphate (Bluestone or Blue Vitriol) is a little more expensive this year than formerly. In spite of the cost, spraying is a crop insurance which is most strongly to be advised.

*Eustace, H. J., Mich. State Board of Agriculture Report 1914:234.

THE SPRAYER.

The type of sprayer depends upon the acreage and method of culture. The market gardener can control tomato leaf-spot with a small knapsack or hand sprayer. Knapsack sprayer for the small grower.

Tomatoes are commonly grown in fields of 5 to 10 acres. For fields of this type a horse-drawn traction sprayer is to be advised. However, efficient work can be secured by means of a handpower barrel pump mounted on a truck. This is the cheapest form suitable for field conditions and may be rigged up for from $25 to $40. Horse-drawn traction sprayer for the ordinary field.

For large acreages or for community or company use, a power sprayer is the best investment. Such an outfit will put the Bordeaux on most efficiently and will give the maximum protection. The sprayer for large acreages.

ARRANGEMENT OF NOZZLES.

Arrange the nozzle to spray upward.

The necessity of spraying the under side of the leaves makes the arrangement of nozzles important. The accompanying diagram shows the arrangement believed to be most efficient.

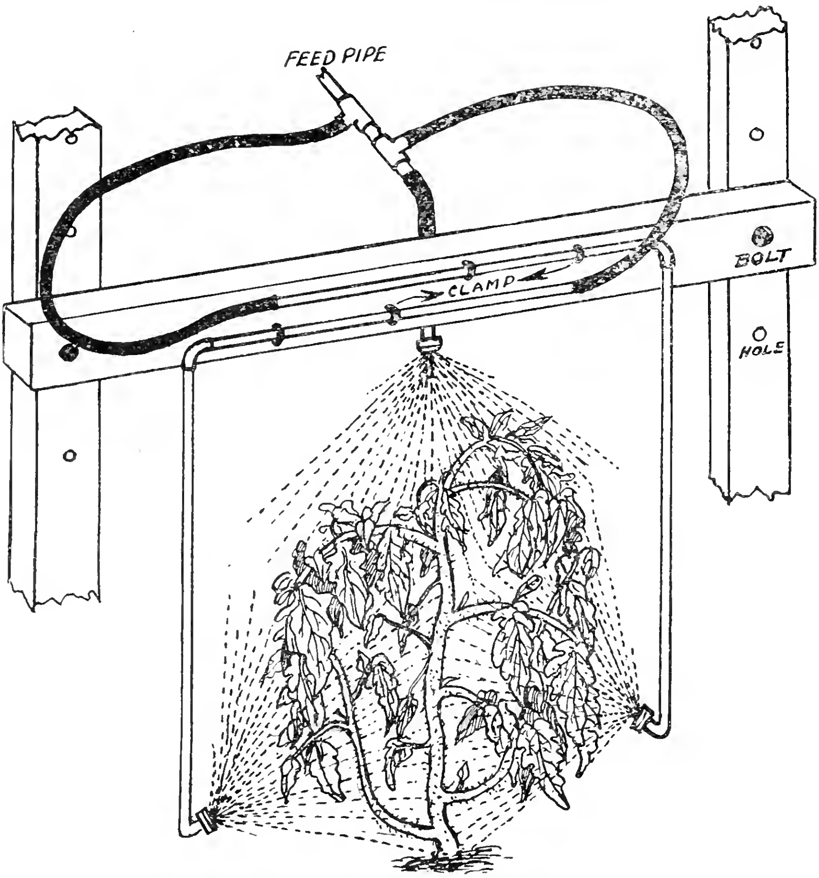


Fig. 5. Arrangement of nozzles.

With such a setting of nozzles the leaves can be efficiently covered without repeating the spray in the reverse direction.

Any spraying outfit can be adjusted to suit the needs of the crop, by use of a few pipe fittings. The accompanying diagram suggests a cheap, easily arranged setting. (Fig. 5.)

Spraying the best you can is better than none at all.

Spraying is worth while even if the outfit is not ideal, or the nozzle arrangement perfect. Given good Bordeaux, thoroughness of application with pressure enough to produce a mist, and the investment will yield good returns.

THE MAKING OF BORDEAUX.

FOR SMALL ACREAGES.

(1) Saw a 50-gallon barrel (vinegar or oil) and make two 25-gallon tubs.

(2) Put 2 pounds of Bluestone (called Blue Vitriol or copper sulphate) in a cloth sack and hang over night in one-half tub of water (12½ gallons). Bluestone dissolves slowly. Hang it the night before so that the sack is just under the surface of the water.

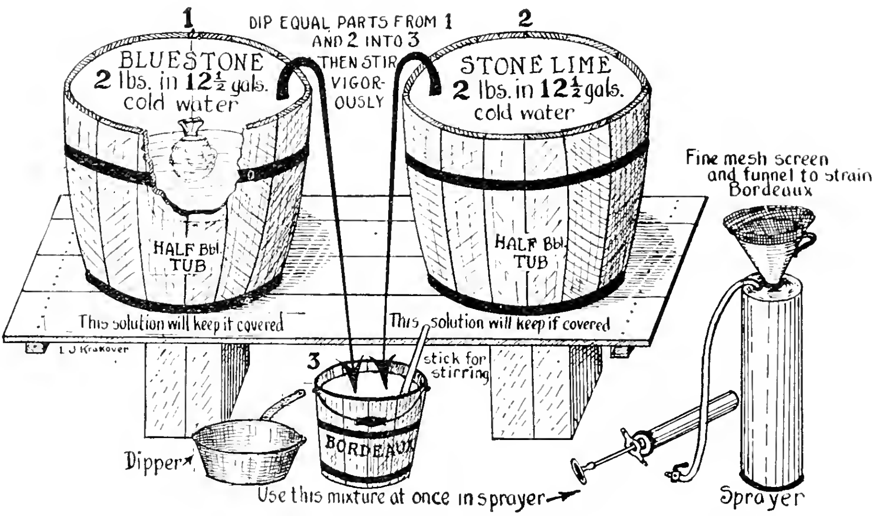


Fig. 6. How to make Bordeaux mixture for small acreages.

(3) Make a lime paste by slaking 2 pounds of fresh stone lime in one-half pail of water. Stir this into the half tub (12½ gallons) of cold water. Hydrated lime (comes in sacks) may be used. Use 2½ to 3 pounds of hydrated. Then follow the directions in the picture. This method will make 25 gallons of spray.

FOR LARGE ACREAGES.

To make 100-gallon batches.

Bordeaux 4-4-50 or 8-8-100 formula.

(1) Secure four 50-gallon barrels.

(2) Fill barrel No. 1 half-full, and hang 25 pounds of Bluestone so that the Bluestone is just under the surface of the water. This makes stock Bluestone, 1 pound to the gallon.

(3) Fill barrel No. 4 half-full of water and stir 25 pounds of freshly slaked stone lime or about 30 pounds hydrated lime in it. This is the stock lime paste, about 1 pound to the gallon.

The stock solutions will make 300 gallons of spray. They will keep if covered.

(4) Take 8 gallons stock Bluestone from barrel No. 1 and add to 42 gallons of water in barrel No. 3. (That is, fill the barrel).

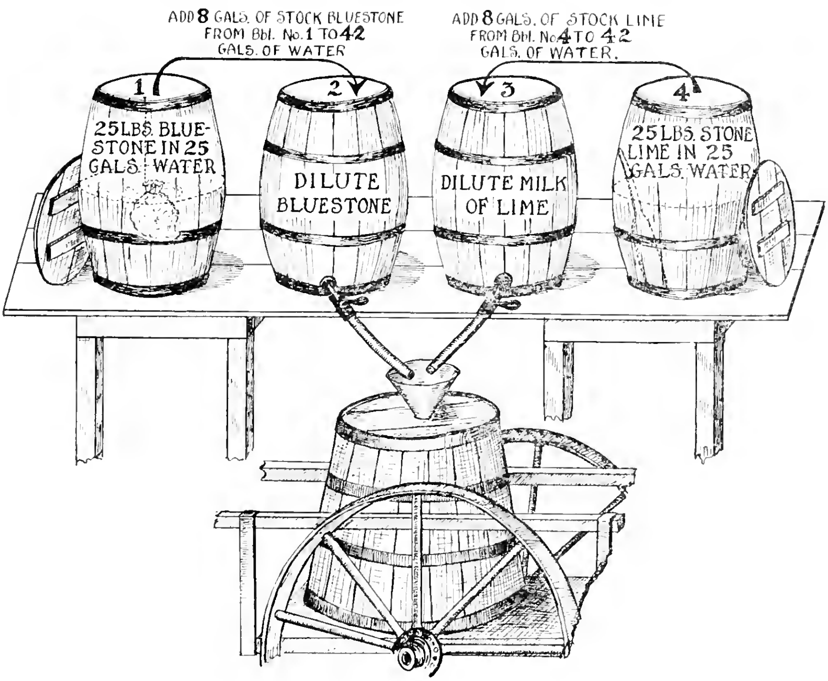


Fig. 7. How to make Bordeaux mixture in 100 gallon amounts.

(5) Take 8 gallons of stock lime from barrel No. 4 and add to 42 gallons of water in barrel No. 3.

(6) Run these materials together through a strainer into the sprayer tank. The combination is Bordeaux mixture and must be applied at once.

If the spray tank holds only 50 gallons make the dilution on one-half the above scale. The first batch may be tested with litmus paper to make sure that there is lime enough. If blue litmus paper turns red, add more lime. *With good fresh lime using the amounts given, no test is needed.* If weather conditions prevent the using of a batch of Bordeaux. it may be kept for a long time if cane sugar is added at the rate of one-half pound to 50 gallons.

THE SOIL SOLUTION OBTAINED BY THE OIL PRESSURE METHOD.

TECHNICAL BULLETIN NO. 28.

FOREWORD.

In my annual report for the year ending June 30, 1913, there appeared a brief account of the efforts of Dr. F. H. H. Van Suchtelen and Mr. Arao Itano to separate from the soil the liquid phase. We encouraged these efforts because we were not satisfied with the results or the promise of results from the then existing lines of research in soil bacteriology, viz.:

I. Numerical determination of bacteria in soil.
II. Determination of species of bacteria in soil.
III. Transformation experiments such as involve determinations of ammonia, nitrites, nitrates, etc.

The soil presents three phases: the solid, the liquid and the gaseous. The study of the soil from any standpoint has always been difficult because of its complexity due to each of these phases and to their interrelationships. It has been our thought and purpose to throw some light on the liquid phase and the present paper contains a description of the method of its extraction, devised by Van Suchtelen and Itano, with some of their results, together with more extensive data relative to the chemical content and physical properties of the soil solution. It has been our thought that such a preliminary study is a necessary preparation for any biological research with the liquid phase of the soil. A further report, involving the micro-biological aspects of the soil solution, is now undergoing preparation.

WARD GILTNER.

THE SOIL SOLUTION OBTAINED BY THE OIL PRESSURE METHOD.

J. FRANKLIN MORGAN, RESEARCH ASSISTANT IN BACTERIOLOGY.

INTRODUCTION.

The study of the soil, the medium in which the plant grows, has been approached from many angles. The sum total of these efforts has thrown some light on what the soil is, what it lacks for good plant growth, and thus what it requires to make up this deficiency. The one phase which has been studied to the least extent is that of the actual medium from which the plant takes part of its nourishment,—that is, the soil solution.

"A solution[1] is a mixture of substances chemically and physically homogeneous throughout, the proportions of whose components may be altered continuously without producing an abrupt change in any property of the solution." It may be more briefly stated: "A solution[2] is a mixture of substances so intimate that they cannot be mechanically separated; as, for example, by filtration."

Soil solution, then, is a homogeneous mixture of the water (the solvent) and the soluble ingredients of the soil (the solutes), consisting of gases, liquids and solids. These solutes may influence the solubility of other substances. This is more especially true of the solutes which makes the solution acid or alkaline in reaction. For example, carbon dioxide dissolved in water forms a weak acid and acids as oxalic, etc., are formed from the decomposing organic substances. Nevertheless the final solvent that holds all in solution is the water.

The somewhat confusing term, soil extract, should not be understood to be the same as the soil solution. The latter is a solution produced by the forces operative under natural conditions. The former is one produced artificially by the use of solvents such as acids or water for the purpose of bringing into solution some particular element or all of the elements in the soil.

THE SOIL SOLUTION IN THE SOIL.

The solid phase of the soil which holds the liquid phase as a medium for nourishing the plants and microorganisms is formed from weathered rock of various kinds and from the decaying organic matter of plants and animals. The amount, size, and composition of the different particles together with the amount of organic matter present determine the type of soil. The maximum amount of soil solution that the soil can hold depends upon the physical character of the soil,—the finer the soil and also the more organic matter, humus, present, the more the particular soil will hold on account of the larger surface given for adsorption. The capillary water present is more firmly held by the force of surface tension.

In order that the plant may take up through its roots the mineral constituents in the soil, the latter must be in solution. As the plant re-

[1]Bigelow's Theoretical and Physical Chemistry (1912 Ed.), p. 36.
[2]Coulter, Barnes and Cowles Text Book of Botany, (1910 Ed.), p. 303.

quires moisture for its existence, the soil water performs a double function,—it furnishes the moisture to the plant, and holds in solution the mineral and the organic compounds. The solutes that are present assist by dissolving some of those constituents of the soil otherwise insoluble. The character or type of soil, e. g., the size and composition of soil particles, will determine to a large extent, what the soil solution contains. Treatment of the soil as to cultivation, drainage, fertilizer and cropping, have a marked influence upon the amount and kind of solutes present.

Gedroitz[1] says that the greatest part of the soil compounds have a very low degree of solubility. The solubility of the soil compounds is not a constant quantity, but depends upon temperature and pressure and as stated previously upon the solutes present. Practically[2] every soil contains all the common rock-forming minerals, all of which are more or less soluble in water, the amount in solution depending upon such factors as the temperature, pressure, etc. Not only these mineral compounds, but the organic compounds formed from decaying plant and animal tissue are found in solution.

The soil solution furnishes material from its immediate surroundings to the plant. The upward movement of the water brings material from below some of which the plant absorbs through its roots. The plant will, on dying, deposit this material on the surface.

HOW ADSORPTION AFFECTS THE SOIL SOLUTION.

A very important factor was brought out by Gola[3] in regard to the colloidal character of the soil particles and its effect upon the soil solution. On account of the complexity and colloidal nature of some of the soil particles, it is claimed that the colloids adsorb some of the salts of the solution. The amount adsorbed depends upon the moisture content. Presence of a large amount of water sets up a dialysis which causes the hydrogels to give up the salts adsorbed. Reverse action takes place at first with a diminution of the moisture content, but finally the imbibition water of the hydrogels evaporates and the gel is precipitated as an amorphorous mass, the bonds uniting the salts with the colloidal molecule are broken, and the water set free is able to dissolve more salts than it can before the loss of the adsorbent properties of the soil.

REAL IMPORTANCE OF THE SOIL SOLUTION.

The study of the soil solution is of a great importance from various points of view. The very complexity of the soil and the constant change which the soil is undergoing introduce a countless play of factors. This complexity inherent in the subject should not discourage investigation. It must be admitted that the soil solutions from different fields or from different parts of the same field will not be exactly the same nor even will the soil solutions present at any one spot remain constant. But the same could be urged against chemical analyses of the soil which likewise vary, yet which on the whole give a general idea of the field conditions.

The soil solution, at the outset, may be considered in its relation to

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[1]Gedroitz: "Solubility of Soil Compounds." Russian Journal of Expt. Landw. 7, 1906, p. 529.

[2]Cameron, F. K.: Soil Solution, 1911, p. 32; Cameron, F. K. and Bell, J. M. The Mineral Constituents of the Soil Solution, Bul. 30, Bureau of Soils, U. S. D. A., p. 9.

[3]F. Cavers' Review of Gola's Osmotic Theory of Edaphism. Jour. of Ecology, Vol. 2, No. 4, 1914. pp. 209-231.

soil formation. Zacharow[1] maintains that the soil solution plays an essential role to the extent in which it relates to the process of leaching, dissolving and further advancement of the soil particles in the soil layer. Finding that the soil extract from different soils varied in color, reaction and amount and composition of the soluble constituents he was able to differentiate the different soil types. The amount of humus present has a marked influence upon the color and reaction of the soil solutions. Soils of the same composition as to type except in organic matter present will vary in their soil solutions as to color and reaction. Varying in these, the other properties, chemical, physical and biological, vary. Not only the humus, but certain of the mineral constituents of the soil that give it color, also have marked influence upon the color of the soil solution.

The second phase of importance from an ecological standpoint is the soil solution as the medium for plant growth, the actual medium in contact with the plant roots, which is the substratum for the microbial life. The plant is susceptible to the neutral, alkaline, or so-called acid reaction and is affected by the amount and kind of available substances present, especially of potassium, phosphorus, calcium and of nitrogen in its various forms.

Cameron and Bell[2] say "The soil solution is physiologically of the greatest importance, as it is the source from which plants absorb the mineral constituents which have been demonstrated to be absolutely essential to their continued existence and development. The study of the soil solution therefore becomes of the first importance in the investigations of the relation of the soil to plant growth."

Heretofore no available means has been devised for obtaining large amounts of the true soil solution or a fair representative of the same. From the study of synthetic solutions and of water extracts, much light has been thrown upon soil fertility. With a true soil solution, much more valuable information ought to be obtained. For example, we have used the soil solution obtained by the method here described to study the effect of the microorganisms in fertilized soils and also to show the effect of soil reaction upon the number and kind of microorganisms present. This phase of the work will be taken up in a later publication.

PREVIOUS METHODS.

1. *Drainage Waters.*

Various investigators have tried to find some means of obtaining a soil solution as it exists in the soil in order that they may become better acquainted with the medium in contact with the plant roots and the medium in which microbial activities must take place. Among the first tried may be mentioned drainage waters.[3]

There are several methods of collecting the drainage water for study:

(a) Collecting the water from the soil drainage pipes at the point of discharge.

[1]Zacharow, S. A.: The Soil Solution: Its Role in the Soil Formation, The Method of Examination and Its Use in the Characterization of Soil Types. Rus. Jour. of Expt. Landw. 1906-7, No. 4, pp. 388-477.

[2]Cameron, F. K. and Bell, J. M. The Mineral Constituents of the Soil. Bul. 30, Bureau of Soils, 1905, p. 8.

[3]Hilgard, E. W., "Soils" (1912) pp. 22-25; Deherain, P. P., Researches on Drainage Water. Ass'n of Agron. Vol. 16-23, Comptes Rendus de l'Acad. des Sci., Vol. 116, 117, 120, 125; Welbel, B. M., Drainage at Plots Expt. Sta., E. S. R., 19, p. 923. Eckart, C. F., Lysimeter Experiments. Haw. Sugar Planters' Sta., Div. Agr. and Chem., Bul. 19, (E. S. R. 18, p. 718; 14, p. 554). The amount and composition of the drainage through unmanured and uncropped land. Barnfield, Rothamsted, Miller, N. H. J. Journ. Agr. Sci. 1 (1906) No. 4, pp. 377-99. (List of 10 references).

(b) Collecting the water that percolates from the bottom of a can that contains a large amount of soil and so arranged as to represent natural conditions.

Some pertinent objections may be brought against this method. The gravitational or drainage water as it moves downward through the soil, carries with it only a small part of the film water, but if it is continued long enough, this film water will be entirely replaced by a new one which for the time being is not concentrated to the same degree as the one before it. Schloesing[1] claims that drainage water, collected after it has passed through a meter of earth, does not faithfully represent the solution which the arable layers imbibe. Lysimeters gave a solution for only a particular depth under certain conditions, but not at any given moment. In all the drainage water, according to Hilgard,[2] the chief nutritive ingredients of plants, except nitrogen, are present in traces only; chlorides, nitrates, sulfates of sodium and magnesium form the bulk of the permanently soluble matter, with usually a considerable proportion of calcic (and magnesic) carbonate depending upon the amount of the earth carbonates present in the soil as well as upon that of oxidizable organic matter from which carbonic acid can be formed. The drainage waters, therefore, contain too much of some ingredients and too little of others to give any definite information as to the soil requirements.

2. *Soil Extracts.*

The method of obtaining soil extracts has, no doubt, been used more than any other for the study of the soil. It depends upon whether a total analysis of the soil is desired, or whether just the ingredients that may become easily available to the plant are desired, as to the nature and strength of solvent used. Different investigators use different solvents for this purpose. The solvents may be classified under three heads: mineral acids, organic acids, and water.

In all the above extractions, none deals with a solution which contains the exact amount of substances available to the plant. While they are certainly valuable for determining the total amount of various ingredients present, it is seriously to be questioned, if they give data on actual soil conditions. Consequently water, the least objectionable, has been used as a solvent for determining the available plant nutrients in the soil.

The methods of obtaining extracts by the use of water vary somewhat. Some use pure distilled water, others distilled water with some gas as CO_2 dissolved in it, others with NH_4Cl in solution. In these two latter methods large amounts of soil and large amounts of water containing CO_2 are used. To one only a small amount of NH_4Cl is added.

The Briggs[3] filter method gives a soil extract. In this method water is mixed with soil in proportions of 5 to 1, and the turbid supernatant liquid is clarified by being forced through a Pasteur-Chamberland filter.

Another common method, the tumbler or beaker method, consists in thoroughly mixing the soil with water and filtering through filter paper. Either a definite amount of water is used, or the soil is washed till the filtrate reaches the desired amount.

[1]Schloesing, Th. Analyse des Eaux contenues dans les terres arables,—Comptes Rendus de l'Academie des Sciences, 1870, 70, p. 99.
[2]Hilgard, E. W. "Soils" (1912) p. 271.
[3]Briggs, L. J., Filtration of Suspended Clay from Soil Solutions. Bul. 19, Bureau of Soils, U. S. Dept. of Agr. p. 31 (1901).

Probably there are conditions that occur in the soil that can be studied by means of the water extracts. These methods while obviously more applicable for yielding data than extractions with acids and the like, yield dilute washings from the soils which cannot be concentrated to reproduce the original soil solution.

3. *Artificial Root.*

In their study of capillary movement of the soil moisture, Briggs and McCall[1] tried to imitate the plant root in its absorption of moisture. A close grained unglazed porcelain filter (Pasteur-Chamberland) was connected to an exhausted 2 liter receiver and was so placed in the soil that there would be good capillary connections. On account of the lower pressure on the inside of the tube, the soil moisture was drawn through. It is claimed that the solution thus obtained is identical in concentration and composition with the soil solution from which plants get their food. The disadvantage of this is that it is applicable only to those soils of comparatively high moisture content and that it furnishes only a small amount of solution. The adsorption on clay filters is known to be important enough to change seriously the solution obtained.

4. *Centrifuge.*

The method for obtaining the soil solution which is least open to criticism is that developed in the Bureau of Soils. I quote from Bulletin 31.

"Dr. L. J. Briggs and Mr. J. W. McLane[2] of this Bureau have constructed for this purpose a centrifugal machine which consists of three concentric cylinders, the middle one having fine perforations. The moist soil sample as collected in the field, is put between the perforated middle cylinder and the inner cylinder. The system of three cylinders is then rotated at a speed approaching 8,000 revolutions per minute. The soil moisture is thrown through the perforations and collects in the compartment formed by the perforated middle cylinder and the outer cylinder. The solution is usually perfectly clear and needs no subsequent filtration. By this means it has been possible to reduce the soil moisture to approximately the optimum condition for plant growth, and this method of obtaining the actual soil moisture is therefore limited to soils containing more than the optimum. Nevertheless, it has been possible to gain some valuable information concerning the actual concentration of the free soil moisture by means of this method, although for any extensive study the amount of solution that can be obtained is comparatively so small as to be practically prohibitive."

5. *Displacement Methods.*

A. Schloesing's method—Water. Historically this type of experiment for obtaining soil solution is quite old. We find progressive development in working out of this method. Among the first attempts to obtain the soil solution in an unaltered condition was that of Th. Schloesing[3] in the '60s. His first method dealt with 1 or 2 kgms but he then modified this plan so as to admit the use of larger amounts of soil, 30 to 35 Kgms. An artificial rain of pure water was so produced that the

[1] Briggs, L. J. and McCall, J. R.: "An Artificial Root for Inducing Capillary movement of Soil Moisture." Science N. S. 20, (1904) pp. 566-8; Bul. 31, Bureau of Soils, U. S. Dept. of Agr. (1901), p. 17.

[2] Schreiner, O. and Failyer, G. H., Colorimetric, Turbidity and Titration Methods used in Soil Investigations, Bul. 31, Bureau of Soils, U. S. Dept. of Agr. (1905) pp. 16-17.

[3] Schloesing, Th. "Sur L'analyse des Principes solubles de la terre vegetable" Comptes Rendus de l'Academie des Sciences. 1866, 63, p. 1007. "Analyse des Eaux Conteneus dans les terres arables" 1870, 70, p. 98.

amount of water falling on the soil could be controlled. The line of demarcation between added water as it percolated through soil and the moisture already in the soil was apparent. In order to make the demarcation more apparent to the eye, he colored the water with carmine. The reason for this being, that the added water forced out the water below before the added water mixed with the soil water. The water thus obtained was used for analytical purposes,—a study of the material in solution. The objection[1] raised to this method was that it did not work well with soils containing less than 20 percent moisture, and the time required for extraction was too long.

B. Istcherekov's method—Alcohol. Istcherekov[2] tried to find some other liquid than water that would wet the soil. With the idea in mind that the attractive forces of the soil particles would be easier to overcome and also that the capillarity would not be destroyed, but somewhat modified, a liquid was desired that would wet the soil and penetrate the smallest pores. The action of such a substance upon moist soil would result in freezing soil solution from the soil. Another requirement was that the displacing liquid should be lighter than water, otherwise the soil solution would rise above the displacing liquid. On account of the less density of the displacing liquid there cannot be mechanical mixing of the two substances. The lighter one floats upon the heavier.

For the purpose of displacing the soil solution he selected alcohol. Either ethyl or methyl could be used. His first experiments dealt with saturated soils. The soil was placed in a glass cylinder, the lower end of which was covered with cloth, and after allowing it to drain, small quantities of alcohol were added. Immediately after each addition a few drops of soil solution dripped down. When the pressure was increased at the top, this dripping increased and thus there was collected 23 c.c. of solution from every 24 c.c. the soil contained. The appearance of a turbid liquid indicated that there was a mixture of the soil solution and alcohol and that the extraction was completed. It is also claimed that soils with a moisture content of 10 to 2 percent were extracted with success. The solution thus obtained was considered a true soil solution. It was suggested that any other liquid could be used provided it fulfilled the above requirements.

C. Gola's method—Imitation Rain. Gola's[3] imitation of rain and pressure method is a combination of soil extraction and displacement methods. A gentle rain was allowed to fall until a regular flow of water was produced from the lower end of the column. This soil is then allowed to stand for 36 hours while the excess water drains out. The soil is then subjected to the pressure of a screw press and the water squeezed out is regarded as a close approximation to the soil solution. The chief objection that Stiles and Jorgensen[4] raise to this method is that it is not applicable to all kinds of soils, but it may be used for all soils having a higher water capacity as clays, loams, humus soils. Gola found that the concentration of the soil liquid varied with the composition of the soils.

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[1]Istcherekov, W. Obtaining of Soil Solution in Unaltered Condition. Russian Jour. of Expt. Landw. 8, 1907, p. 147.

[2]Istcherekov, W. ibid pp. 147-165.

[3]Gola's (Oswerverzioni Sopra i liguidi Cirolanti nel terreno Agrario) Ann d. R. Acad. Aric. di Lorino 54, 1911; Cavers, F. G. Gola's Theory of Edaphism. The Jour. of Ecol. 1914, 2, No. 4 p. 217.

[4]Stiles, W. and Jorgensen, I. "The Nature and Method of Extraction of the Soil Solution," The Jour. of Ecol. 1914, 2, No. 4, p. 249.

D. Van Suchtelen's Method—Paraffin oil. Van Suchtelen[1] impressed by the feasibility of the Istcherekov's method, modified the plan and after some preliminary work (which will be taken up later) selected paraffin oil as a displacing liquid for obtaining the soil solution in its natural condition.

A large Buchner filter was prepared with a thin layer of non-hygroscopic washed-out Gooch asbestos. The asbestos was treated with alcohol and ether and after that it was dried for some time. The fairly moist soil, whose moisture content was known, was spread upon the asbestos and lightly pressed down with a rubber stopper. Then cooled paraffin oil was poured on so that the entire surface was covered, whereupon a slight suction was used. The liquid thus obtained was heated to 40° C. for a very short time in the suction flask in order to diminish the viscosity. After that it was carefully poured into a centrifuge tube and in order to hasten the separation, it was centrifuged for a few minutes at a moderate speed. By means of a separatory funnel, the heavier water was separated from the lighter paraffin oil. The paraffin oil, if it was entirely clear, without air bubbles, could be used again. The water content of the soil, in which the soil water was displaced by the paraffin oil, lies according to his experiments under 50 percent of the total water capacity.

PRESENT METHODS.

Paraffin oil displacement—pressure method.

Later, instead of using suction as described above, some kind of pressure method was undertaken by Van Suchtelen and Itano with the idea that if a greater force could be applied than could be obtained with the suction pump, better results would be attained. Therefore another apparatus was necessary. In this apparatus the displacing liquid was forced through the soil instead of being pulled through by suction. It is with this apparatus and with the solution obtained that the author has been experimenting for over two years.

Apparatus.

This consists of a cylinder connected at the top with a high pressure pump and open at the bottom with a small bored spout from which the soil solution flows. The details of the construction may be seen from the accompanying diagram and descriptions. After trial with a cast iron cylinder 5 inches in diameter and 22 inches long, others were made later, of larger dimensions, 6 inches by 24 inches. The cylinder is screwed into a flange and reducer. The union is soldered in order to make a more perfect joint. The reducer is connected to the pedestal, the upper part of which is hollow, while the part below the spout is plugged (to prevent loss of solution). This entire lower part can be easily removed from the cylinder for cleaning purposes. The cap is fastened on with bolts. A gasket of copper and asbestos is used to make a tighter joint. In the bottom of the cylinder is placed a perforated plate and above this two fine wire gauzes to hold back the soil. These gauzes are larger than the plate to prevent the soil from passing under its edge. A series of cylinders can be arranged in a battery, so that all can be worked at the same time, or any one or two cut out. In our experiment, three were so

[1]Van Suchtelen, F. H. H., Methode zur Gewinnung der Natürlichen Bodenlösung. Jour. f. Landwirt, 1912, 60, pp. 369-70.

connected. For this purpose any kind of hand pump can be used that will force the liquid through under pressure. The gage is an ordinary 500 lb. steam pressure gage and is placed on the main line so that the pressure can be read on any cylinder of the battery, by putting in or cutting out the cylinders from the pressure pump.

The small cylinder (5 inches by 22 inches) is capable of holding 28 to 33 lbs. of soil depending upon the nature of the soil, while the larger ones (6 inches by 24 inches) hold 35 to 50 lbs.

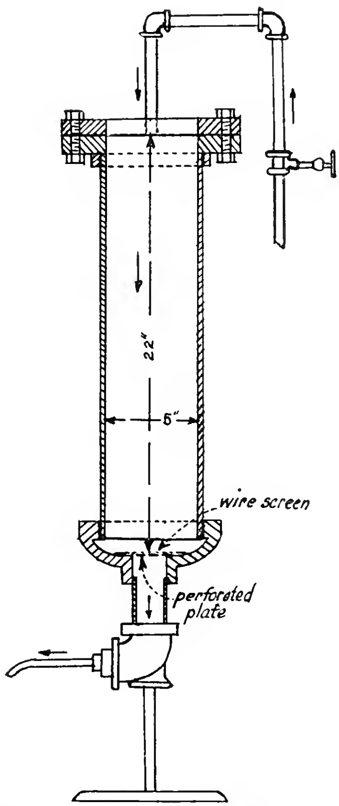

FIGURE 1. LONGITUDINAL SECTION OF THE SMALL CYLINDER. NOTE THAT WIRE SCREEN (USUALLY 2) OVERLAPS THE PERFORATED PLATE.

Before using the cylinders the inside is coated with hot paraffin; in order to keep the soil and the solution away from the iron. The lower pipe and spout as well as the plate and gauze in the bottom are also treated in like manner.

The cylinder is weighed before and after filling in order to get the weight of the soil used. The soil used is thoroughly mixed by rolling it back and forth on a large piece of oil cloth. The soil is added in small quantities (about a double handful) at a time, a small portion being saved each time for a composite moisture sample. The soil in the cylinder is thoroughly packed down by means of a stick with an iron disk on the end. A great deal depends upon the packing. If loosely

packed, or unevenly packed, there will be left an easy channel for the displacing liquid to pass without much pressure being exerted and also without obtaining the total amount of solution possible. The pressure exerted will depend upon the moisture content of the soil. It is raised gradually as long as moisture continues to come until finally 500 lbs. pressure is used if the oil has not come through before the pressure reaches this maximum. One reason why the pressure is raised gradually is to give the soil an opportunity to adjust itself and thus to pre-

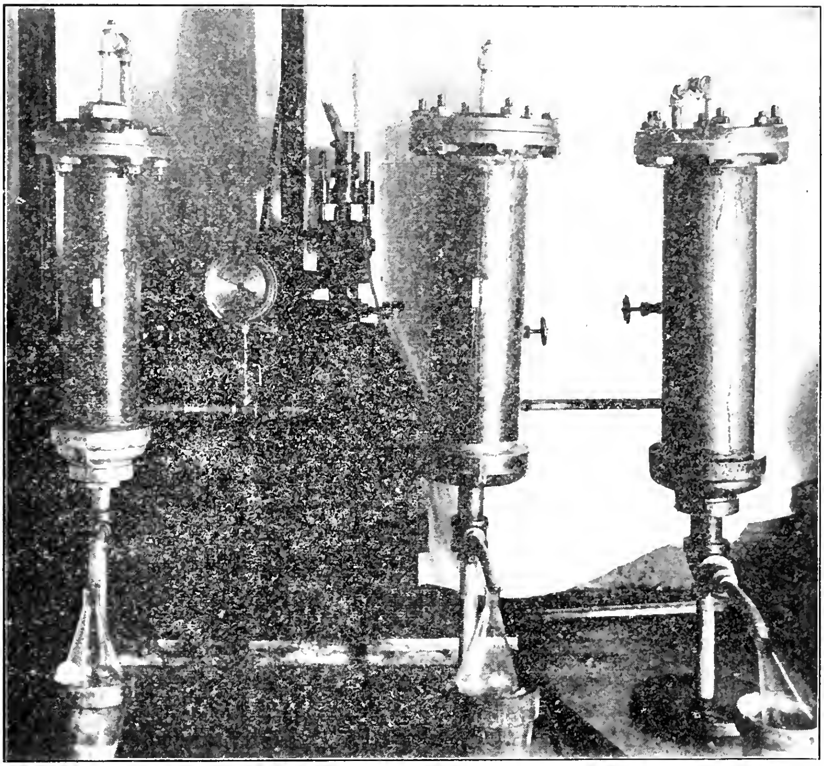

PLATE 1. BATTERY OF 3 CYLINDERS SET UP FOR USE SHOWING THE MANNER OF CONNECTION, GAGE AND PUMP AND ALSO THE WAY THE SOLUTIONS WERE COLLECTED.

vent the oil from coming through too soon due to the formation of channels. Some soils with a very high moisture content will, even on packing, give off some of the solution that they contain.

When the oil comes through in any of the cylinders, the valves on the others are closed to hold the pressure attained, while the pressure is being released on the first by opening the release valve on the pump. After this, the operation is reversed and the pumping is continued as before. When all the cylinders are used for extraction of the same soil, all extractions, if mixed, will give an abundance of material to work with. In the sandy soils, oil will make its appearance generally from 3 to 9 hours, while with the finer grained soils the oil may not come through

for several days. Solutions for analysis are hardly ever used after a protracted (48 hour) extraction. Solutions are gathered from time to time and placed in a refrigerator to retard the bacterial action. Care is taken to prevent chemical changes in the solution by using resistance glass.

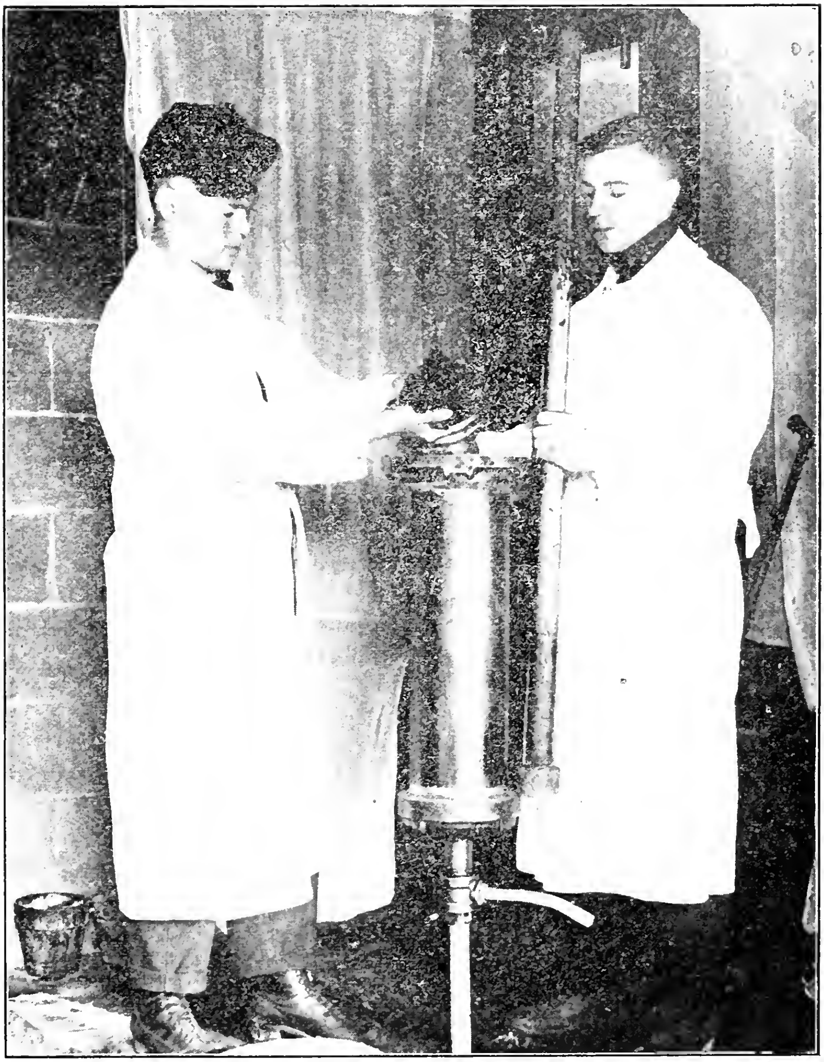

PLATE 2. FILLING THE CYLINDER. LITTLE OF EACH HANDFUL IS TAKEN FOR A COMPOSITE SAMPLE FOR MOISTURE DETERMINATION. STYLE OF TAMPER IS ALSO SHOWN.

When cleaning out the cylinders, the oil that is superimposed on the soil is saved and can be used again provided one strains it to get rid of the dirt that it might contain. It is found that in order to clean out

the cylinders easily, it is best to bore into soil either with an ordinary soil auger or with an ordinary 3-inch bit, (with the former several holes will be necessary), then with a bar the soil may be pried from the sides and taken out quite readily and in soils, like clay, sections of soil may be pulled out with the soil auger which acts like a cork screw. To remove the soil in the bottom of the cylinder unscrew the cylinder from its pedestal and invert it, then, through the opening in the bottom, one can force the soil out by driving on the perforated plate with a piece of pipe and hammer. The soil in the bottom will be found to be packed harder and drier than that at the top.

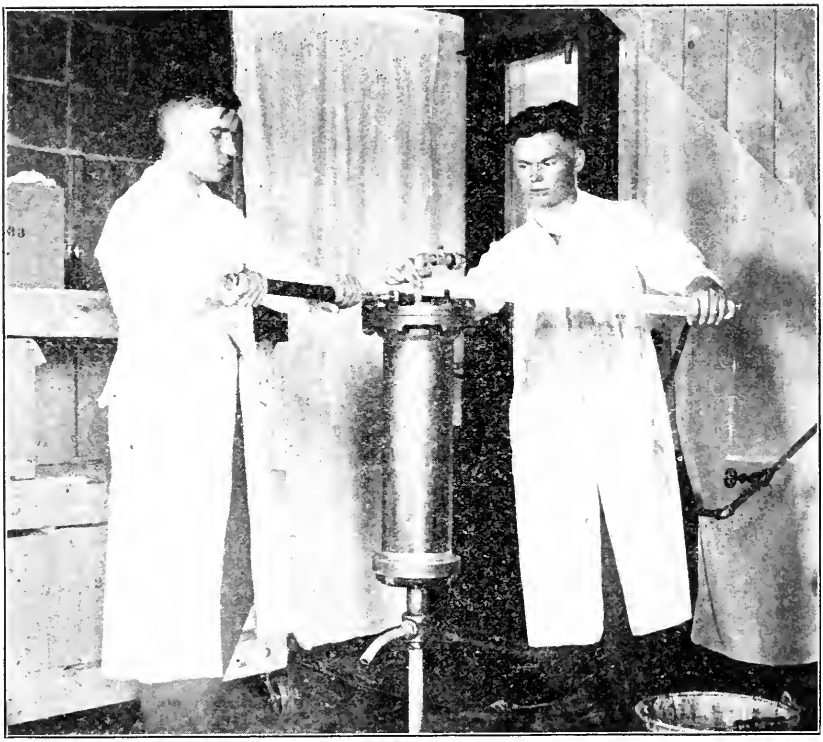

PLATE 3. METHOD OF SCREWING ON THE TOP. THE BAR ON THE LEFT IS USED TO PREVENT THE CYLINDER FROM TURNING WHILE THE BOLTS ARE BEING TIGHTENED. THE TOP NEEDS TO BE FASTENED TIGHTLY TO PREVENT THE OIL FROM OOZING OUT ON ACCOUNT OF THE HIGH PRESSURE USED.

Displacing Liquid.

The selection of the displacing liquid is very important. Istcherekov[1] claims that the displacing liquid should wet the soil. A substance that will not wet the soil will not penetrate the latter when the soil is packed but may pass through the larger pore spaces only. On the contrary a substance that wets the soil, as well as the water does, will drive the moisture downward, provided that the displacing liquid is lighter than

[1]Istcherekov, W. The obtaining of Soil Solution in Unaltered Condition. Rus. Jour. of Expt. Landw. 8, 1907, p. 150.

water. Paraffin oil fulfills part of the above requirements in that it is lighter than water, but does not wet the soil, that is, it is not attracted to the soil particles like water. An advantage that it has over alcohol is its inertness; it does not act upon the soil, nor does it mix with the soil solution. Whatever oil comes through with the solution can be easily separated by cooling the flask so that the oil will adhere to the sides and then the water can be poured off. A thick viscous cylinder oil was used in making the extractions. If, at times, this oil became too thick for pumping, it was thinned slightly by a less viscous one.

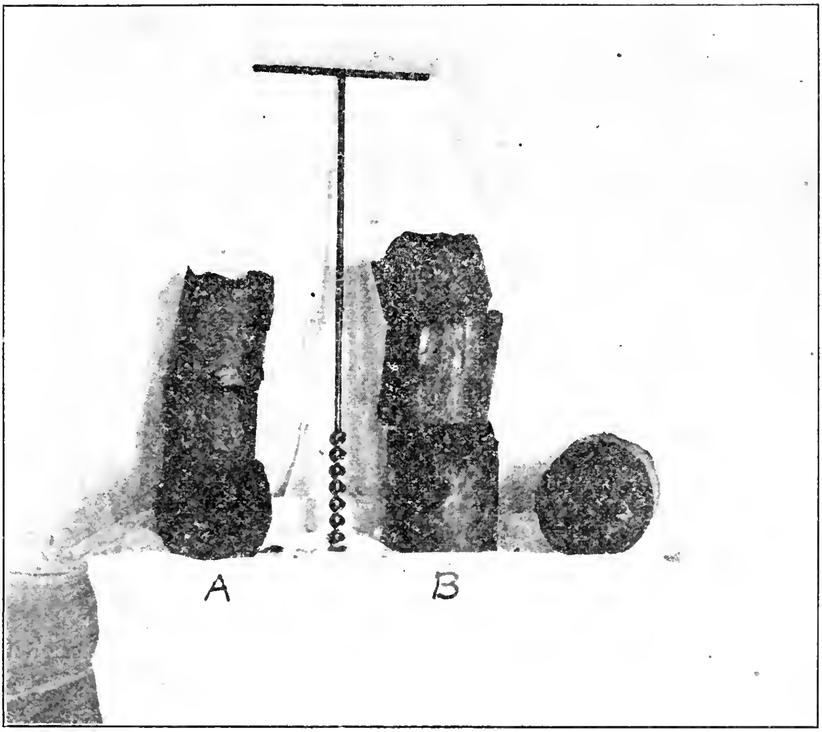

PLATE 4. SECTIONS OF SOILS TAKEN FROM CYLINDER AFTER EXTRACTION BY MEANS OF THE SOIL AUGER. A, FROM SMALL CYLINDER; B, FROM THE LARGE ONE. THESE ARE VERY COMPACT AND HARD.

Van Suchtelen and Itano[1], to prove the inertness of the oil, made the following experiments:

1. To see if the oil has an influence on the surface tension of the water they first determined the number of drops falling from a specially arranged pipette filled with distilled water, and compared the results obtained with another portion of the distilled water, shaken with the oil for 20 minutes and counted at a temperature of 16.6° C.

[1]From Van Suchtelen and Itano's unpublished work done in this laboratory.

TABLE I.—THE EFFECT OF PARAFFIN OIL ON THE SURFACE TENSION OF DISTILLED WATER.

Trial.	Dist. water. Drops.		Dist. water shaken with oil. Drops.	
1	130		127	
2	128	128.3	125	126.
3	127		126	

From the above they concluded that the oil has no influence upon the surface tension. They extracted peat with hot water and filtered and used such a solution because changes would more readily reveal themselves, due to the variable and complex nature of the substances in the solution. A large amount of finely sliced paraffin was introduced into 200 c.c. of the solution and the conductivity determined after one-half hour, one hour, and three hours. In each case, it was exactly the same, —0.00147 ohms.

2. In the test of the effect of the oil on the soluble salts, the solution was kept with a trace of $HgCl_2$ to prevent biochemical changes taking place. The resistance was measured after contact with oil lasting 1, 2, 3, 4 and 14 hours, without any change whatsoever. In check experiments where the time of contact was even 24 hours, no change could be detected.

To make sure that no disturbing influences were present during the extraction, electrical conductivity was measured of successive portions of 40 c.c. of the soil solution as they flowed out of the cylinder.

TABLE II.—COMPARISON OF ELECTRO-CONDUCTIVITY OF SUCCESSIVE PORTIONS OF SOIL SOLUTION.

A[1]			
1	40 cc.	0.000640	
2	40 cc.	0.000639	
3	40 cc.	0.000642	Av. 0.000642
4	40 cc.	0.000645	

Where larger portions were taken and time of extraction was longer:

	Cylinder 5″ x 22″			Cylinder 6″ x 24″		
B.						
1	538 cc.	0.000863		545 cc.	0.000916	
2	450 cc.	0.000889		545 cc.	0.000916	
3	445 cc.	0.000901	Av. 0.000895	530 cc.	0.000920	
4	167 cc.	0.000928		540 cc.	0.000904	Av. 0.000912
5	....	....		250 cc.	0.000901	
6	....	....		225 cc.	0.000904	
7	....	....		150 cc.	0.000924	
C.						
1	212 cc.	0.000238		200 cc.	0.000257	
2	103 cc.	0.000255	Av. 0.000247	220 cc.	0.000246	Av. 0.000259
3	....	....		95 cc.	0.000273	

A[1] This portion of table only, from Van Suchtelen and Itano's unpublished work.

In nearly every case there was a slight increase in the last determination over the first. None of the changes were very marked and varied in both directions. The total solids vary somewhat similarly as will be seen in Table V under Soil, Nos. 34 and 35.

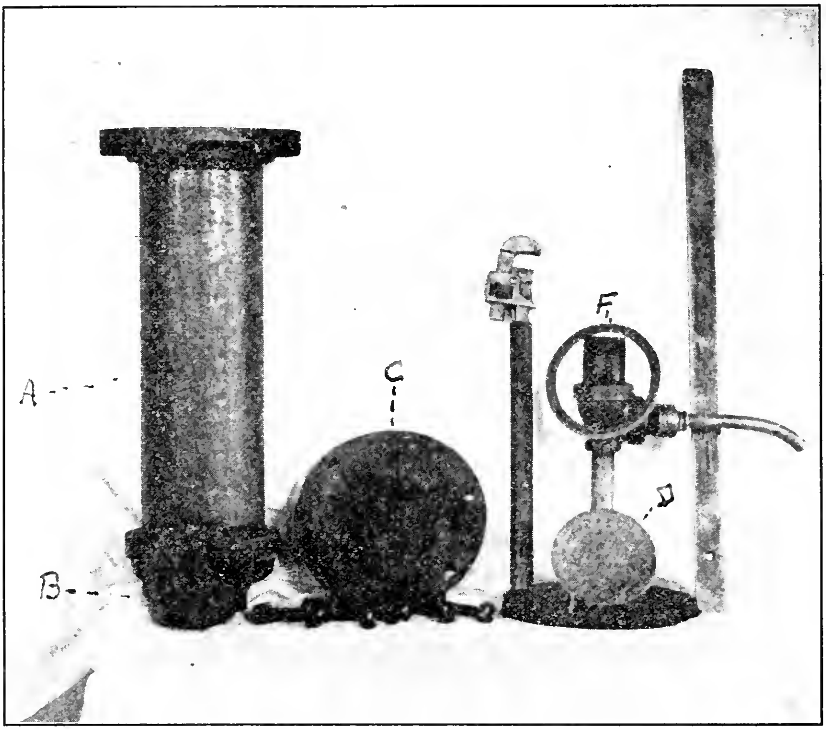

PLATE 5. DIFFERENT PARTS OF THE EXTRACTION APPARATUS AND WRENCH AND BAR FOR FASTENING ON THE TOP. A, CYLINDER; B, WIRE GAUGE; C, COVER; D, PERFORATE PLATE; E, PEDESTAL AND SPOUT; F, COPPER GASKET.

Soil.

This method can be used with all kinds of soils, but it is better adapted to the coarser and more porous soils like the sandy and sandy loam soils than to the finer grained and less porous soils as the clays and clay-loams.

Moisture Content and Solution Obtained.

This method will not give the entire moisture content, nor will any method yet devised give the entire moisture content as it exists in the soil. The moisture content that is necessary for an extraction will depend upon the nature of the soil used. If it contains a large amount of organic matter or if the grain size is very small, a larger moisture content is necessary than if the reverse is true. The amount of solution that can be obtained from the soil will depend upon three factors:

1. Moisture content of the soil.
2. Kind of soil.
3. The packing of the soil.

The greater the amount of moisture present up to its total water capacity, the more solution can be obtained. It is assumed that everything else being equal, all the solution above a certain point can be obtained. Briggs and McLane[1] in their work with the centrifuge called this point the *moisture equivalent*, being that amount of moisture retained by the soil, when the moisture content is reduced by means of a constant centrifugal force until it is brought into a state of capillary equilibrum with the applied force. The same term may be applied here with the understanding that it may vary due to the application of a different force. If we consider the work of these men[2] we note the force with which the water film is held to the soil particles. In the whirling of moist soils, they find that this film was not removed by a force of 3,000 times the force of gravitation. In the paraffin oil pressure method, the highest pressure used was only 550 to 600 pounds or about 40 atmospheres. The thicker the film around the soil particles the less force is required to remove the moisture from the outer edge of the film. Lord Rayleigh[3] as a result of some experiments calculated that the thin film was held with a force as high as 25,000 atmospheres. With part of the moisture held by that great force, it would be impossible to get it all with 40 atmospheres. On account of the oil penetrating at least part of the soil, sides, top and bottom, and all of some soils, the amount of moisture that remains is obtained by the difference between the moisture content of the soil and that obtained by extraction.

In Table III the extractions are classed according to the kind of soil used. The letters S and L refer to the small and large cylinders respectively. The percentage of moisture in the soil (M. in S.) is based on oven dried soil. The weight of soil (Wt. of S) used in the extraction includes over dried soil plus the moisture in the soil; that is, it is the weight of the moist soil. The percentage of moisture extracted is based upon oven dried soil, while the percentage of the moisture in the soil (M. in S.) extracted is based upon the total moisture content of the soil. The moisture equivalent (M. E.) obtained is the difference between the percentage of moisture in the soil and that extracted, while the moisture equivalent calculated is determined from their formula[4] based upon the mechanical analysis of the soil.

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[1]Briggs, L. J. and McLane, J. W. The Moisture Equivalents of Soils. Bul. No. 45, Bur. of Soils, U. S. Dept. of Agr. pp. 5, and 22.
[2]Briggs, L. J. and McLane, J. W. Ibid. pp. 14 and 23.
[3]Lord Rayleigh, On the theory of surface forces. Phil. Mag. S. 5, V. 30, pp. 285-298, 456-475. (1890).
[4]Briggs, L. J. and McLane, J. W. Ibid. p. 17.

TABLE III.—MOISTURE CONTENT OF SOIL AND AMOUNT EXTRACTED.

A.—Fine sandy soil (surface).

Lab. No.	Percent of M. in S.	Wt. of S. used. Kgms.	C. C. Extr.	Percent Extr.	Percent of M. in S. Extr.	M. E. obtained Per cent.	M. E. calculated. Per cent.
1	S. 42.02	10.00	330	4.68	11.10	37.34	13.64
	S. "	10.72	385	5.10	12.25	36.92	
2	S. 46.73	9.87	395	5.85	12.58	40.98	13.64
	S. "	9.87	370	5.47	11.82	40.26	
18	S. 29.74	12.28	690	7.31	24.58	22.43	5.86
	L. "	19.59	1630	10.81	36.37	18.93	
18a	S. 22.87	13.04	650	6.13	26.81	16.71	5.86
27	S. 40.77	11.79	455	5.41	13.35	35.33	13.64
	L. "	18.14	770	5.98	14.67	34.79	
28	S. 46.02	11.79	675	8.36	18.18	37.66	13.64
	L. "	18.14	1165	9.06	20.14	36.96	
29	S. 43.98	11.57	530	6.60	15.04	37.38	13.64
	L. "	18.14	800	6.35	14.44	37.63	
35	S. 7.66	12.70	315	2.67	34.87	4.99	3.57
	L "	20.41	515	2.72	35.47	4.94	

18a was soil not touched with the oil taken from the cylinders of 18 and extraction made without the addition of any more water.

B.—Fine sandy soil (subsoil).

Lab. No.	Percent of M. in S.	Wt. of S. used. Kgms.	C. C. Extr.	Percent Extr.	Percent of M. in S. Extr.	M. E. obtained Per cent.	M. E. calculated. Per cent.
30	S. 23.18	13.83	1320	11.76	50.19	11.42	4.02
	L. "	21.55	1800	11.43	42.88	11.77	
32	S. 17.35	14.29	1290	10.63	61.19	6.72	4.02
	L. "	22.34	1550	8.15	46.95	9.20	
33	S. 17.71	14.29	1487	12.26	69.22	5.45	4.02
	L. "	22.23	2475	13.12	74.08	4.59	
34	S. 21.08	14.06	1600	13.77	65.36	7.31	4.02
	L. "	22.01	2785	15.29	72.73	5.79	

C.—Medium sandy soil (Saginaw) surface.

Lab. No.	Percent of M. in S.	Wt. of S. used. Kgms.	C. C. Extr.	Percent Extr.	Percent of M. in S. Extr.	M. E. obtained Per cent.	M. E. calculated. Per cent.
3	S. 24.80	9.92	275	3.11	9.64	21.69	9.11
	S. "	11.77	875	9.88	29.98	14.92	
3a	L. 27.49	17.24	1900	14.38	54.77	13.11	9.11

D.—Medium sandy loam.

Lab. No.	Percent of M. in S.	Wt. of S. used. Kgms.	C. C. Extr.	Percent Extr.	Percent of M. in S. Extr.	M. E. obtained Per cent.	M. E. calculated. Per cent.
4	S. 29.36	12.56	350	3.61	12.29	25.75	
	L. "	19.28	420	2.82	12.46	26.54	
	S. "	12.36	330	3.46	11.51	25.90	15.68
	S. "	12.62	320	3.28	11.19	26.08	
4a	S. 27.24	10.40	375	4.59	16.86	22.65	15.68
	L. "	19.85	760	4.88	17.92	22.36	
17	S. 45.38	11.34	830	10.66	23.48	34.72	*8.11
	L. "	17.69	1715	14.09	31.01	31.29	

*Low on account of not considering the presence of organic matter.

E.—Miami Silt Loam.

Lab. No.	Percent of M. in S.	Wt. of S. used. Kgms.	C. C. Extr.	Percent Extr.	Percent of M. in S. Extr.	M. E. obtained. Per cent.	M. E. calculated. Per cent.
24	S. 37.81 L. "	12.47 18.37	159 231	1.76 1.73	4.65 4.59	36.05 36.08	23.68
25	S. 36.69 L. "	12.70 18.84	173 286	1.87 2.03	5.22 5.92	34.82 34.63	23.68
26	S. 35.12 L. "	11.79 19.28	700 1125	8.03 7.89	22.85 22.17	37.09 37.23	23.68

F.—Clyde clay loam (subsoil).

*39 *39a	L. 54.61 L. 46.88	18.31 19.16	87 few drops	0.78	1.22	53.83	28.70 ....
42	S. 40.86 L. 40.86	13.38 20.21	214 298	2.25 1.98	5.51 4.85	38.61 28.88	28.70

*Small amount of moisture obtained in these extractions was due to soil coming thru and plugging the spout. Wire gauze did not cover the perforated plate entirely.

G.—Clyde fine sandy loam (surface).

†40 40a	L. 43.82 L. 40.57	19.56 19.91	91 265	0.67 1.87	1.53 4.61	43.15 38.70	24.58
41	L. 41.91 L. "	19.73 19.85	491 433	3.53 3.10	8.42 7.38	38.88 38.81	20.95

†See note of 39 and 39a above.

H.—Miami clay (surface).

43	L. 24.52	23.02	264	1.43	5.80	23.09	15.14

I.—Peat.

22	S. 132.90 L. "	8.73 13.84	730 1212	19.95 24.43	14.64 15.37	112.95 112.80	....
23	S. 251.95 L. "	7.48 10.89	1249 1825	58.79 59.05	23.33 23.44	193.16 192.90	....

J.—Muck.

19	L. 98.22	13.32	125	1.86	1.89	96.36	35.89
20	S. 155.01 L. "	8.16 12.93	600 800	18.75 15.79	12.10 11.68	136.26 139.22	41.58
21	S. 161.00 L. "	8.39 12.70	660 860	20.80 17.90	12.68 10.92	143.20 146 10	41.58

Under D. 4 L., this cylinder cracked around the flange before extraction was completed.

From Table III it will be noted that the amount of moisture extracted depends upon the kind of soil. With some soils the percentage extracted is very high. For instance, from the sandy soils Nos. 32 S, 33 and 34 of B, from 59 to 74 per cent of the moisture content of the soil. No. 35 of A (7.66%) 35 percent of the soil moisture was removed and considering the low moisture content, it is to be seen that the extraction was very efficient.

From the column showing the number of c.c. extracted, it is evident that sufficient amount of solution is obtained in nearly every instance from a single cylinder for analytical purposes. In the majority of the extractions the larger cylinder gave better results,—more solution in proportion to the amount of soil used than the smaller one. In some cases there was not much difference in the results.

In a series of extractions with Soil 18, a variation from the usual practice occurred, which showed further possibilities of the method. Soil No. 18 of A was received from Saginaw in a nearly air dry condition with a moisture content of 6.25 percent (oven dried basis). Sufficient ammonia-free distilled water was added to this soil the night before the extraction was made to make a total moisture content of 29.74%. After the extraction was made, that portion of the soil untouched with oil was removed and served for a second extraction (18a) on the same day. The amount derived as a result of both extractions equals 43.71 percent of the total moisture content present at the beginning of the first extraction. The percentage of moisture in 18a corresponds very closely to the average of the moisture equivalent obtained for the small and large cylinders of Soil 18. From Soil 3 of C, a Saginaw soil, whose moisture content was 11.56 percent no solution could be obtained. Ammonia-free distilled water was added and extraction was made and results were obtained as noted in the table. Soil 3a was another portion of the same soil whose moisture content was raised 8 months later and extracted. Soils 4 and 4a of D were the same soil obtained at the same time, stored in large galvanized iron pails paraffined to keep the soil from the sides of the pail and was covered with paraffn to prevent loss of moisture. The extractions were made at different times. Soils 39 of F and 40 of G were obtained a week before the extractions were to be made for the purpose of dividing each sample into two portions and raising the moisture content of one portion of each sample. Likewise soils 42 of F and 43 of H were obtained, but no change was made in its mosture content. Soil 41 of G was obtained two days before the extraction, while all the others were used on the day of collection.

The moisture equivalent obtained, especially of those sandy soils with a low percentage of organic matter present, approached quite closely that calculated. This is notable in 35 of A, 32, 33, and 34 of B. Most of them are within the limit of error $\pm$ 3 allowed by Briggs and McLain[1]. This is not true of the other soils. Perhaps this may be partially explained by the fact that the oil penetrated the former soils, but did not penetrate the latter soils. The moisture equivalent of the peat and muck soils is very high. From such high moisture content one might expect a greater volume of the solution than was obtained, but, it indicates how tenaciously the soil water is held by the organic matter. Another fact

[1]Briggs, L. J. and McLane, J. W. Ibid. p. 18.

TABLE IV.—MECHANICAL ANALYSIS OF THE SOILS USED.

Laboratory number of soils used. Percentage of.	1, 2, 27, 28, 29.	24, 25, 26.	18, 18a.	3, 3a.	4, 4a.	17.	30, 32, 33, 34.	35.	39, 42.	40.	41.	43.
Coarse gravel (above 2 mm.)	....	....	....	....	0.95	....	....	....	....	....	....	....
Fine gravel (2-1.0 mm.)	0.61	0.29	....	0.29	2.08	6.26	0.95	0.39	3.448	3.302	6.066	1.669
Coarse sand (1-.5 mm.)	3.21	1.52	1.04	1.80	3.92	6.85	2.50	3.58	13.850	9.000	9.690	1.032
Medium sand (5-.25 mm.)	20.79	3.16	28.09	34.32	20.56	31.90	33.44	32.72	11.654	10.898	9.190	3.462
Fine sand (.25-.10 mm.)	49.26	6.87	50.73	35.85	17.02	23.70	51.77	50.57	7.610	15.286	11.170	6.238
Very fine sand (.10-.05 mm.)	10.19	9.33	11.13	10.45	7.18	3.70	6.13	6.04	11.530	20.630	27.250	16.148
Silt (.05-.005 mm.)	13.21	65.52	6.57	13.26	30.44	20.70	1.81	4.52	11.098	20.098	16.400	14.918
Clay (below .005 mm.)	2.72	13.32	2.42	3.77	17.85	7.03	3.16	2.13	32.808	20.786	20.234	56.536
Organic matter or volatile matter	15.28	10.85	4.02	6.58	....	....	1.49	1.17	9.851	12.448	11.997	5.998

NOTE.—The analyses are not an average determination of the various numbers in the respective columns, but of one sample taken where those soils were obtained.

should be noted, viz. that a much greater force was used and applied differently by the above men than that used in our experiments. It must be noted that the moisture equivalent will vary according to the force applied.

If we consider Tables III and IV together, we will find that those soils with the finer particles and also those with more organic matter have a tendency to hold back the water very tenaciously. This is very noticeable in the soils of the sandy loam, silt loam, clays, muck and peat types. Even in the centrifuge method, those containing a larger percentage of the finer grain and organic matter retained a larger percentage of the moisture.

PROPERTIES OF SOIL SOLUTION.

The study of certain of the physical, chemical and biological factors of that solution ought to give some information in respect to the soil problems.

Physical.

The specific gravity of the solution gives an index of its concentration. It is necessary for the calculations of viscosity and surface tension and is determined by the pycnometer at 18° C.

The color of the solution may give some indication as to the presence of organic matter, perhaps something as to the nature of that organic matter. The author has noticed in some box experiments where the soil was treated with a large amount of dried blood, tankage or cotton seed meal, a distinct coloration of the solution. However any information gained in this connection must be very indefinite.

Other things being equal turbidity shows something as to the fineness of the soil,—the finer it is, the more turbid the solution. The larger and heavier particles can be separated after a few minutes centrifuging. Some of the remainder will settle out after long standing. The turbidity is determined by making a comparison with a known mixture of $BaSO_4$ and water by means of Schreiner's colormeter. The above mixture is made by mixing 1 cc. each of N/10 $BaCl_2$, and N/10 K_2SO_4 and diluting to the desired strength. As in the case of color, data collected in connection with turbidity are of questionable value at the present stage of our studies.

Surface tension and viscosity are very important in that they have much to do with the capillary movement of the soil water. The greater the surface tension, the thicker will be the capillary film and the harder it will be to remove this film. The more viscous the liquid is, the less will be the movement due to capillary action. The surface tension is determined by the drop method, that is, comparing the size of a drop of the solution with that of distilled water at a given temperature. Traube's Viscostagonometer[1] is considered the best instrument for this work in that it could be used both for the determination of surface tension and viscosity. With a little care both could be run at the same time. The apparatus consisted of a long graduated tube which is joined at the lower end to a narrow capillary tube ending in a polished dropping surface. The tube is graduated into 50 divisions and holds 2 or 3 c.c. of liquid. The liquid is drawn up by suction through a rubber tube attached to the top of the glass tube either by a pump or the mouth. The

[1]E. Abderhalden, "Kapillaranalylisch Methoden von J. Traube," Handb. Biochem. Arbt. Meth. B. V., pt. 2, p. 1358 and Seq.

author finds that better results were obtained by removing the rubber tubing in either case, otherwise the flow will be hindered by shutting out the free access of air. Traube recommends the use of two mirrors so arranged that one can notice when the first drop falls while taking the reading on the upper part of the scale. The author finds it easier to allow the first drop to fall into the hand while taking the reading. This is only necessary for surface tension work. The number of drops is counted and the reading is also taken for the last drop. From the data thus obtained, the size of the drop is determined. The size of the drop of distilled water is also determined and the two compared, the size of the drops is obtained by dividing the number of the divisions of the pipette delivered by the corresponding number of drops. The time it takes for the solutions to pass through fifty divisions of the pipette divided by the time for distilled water to pass through the same number of divisions gives the viscosity.

$$\frac{\text{Size of drop of solution} \times \text{Sp. Gr.}}{\text{Size of drop of dist. water} \times \text{Sp. Gr.}} = \text{Surface Tension of Solution.}$$

$$\frac{\text{Sp. Gr. of solution} \times t}{\text{Sp. Gr. of Dist. Water} \times t'} = \text{Viscosity of Solution.}$$

As temperature influences the flow and amount of liquid used, the tube is surrounded by a water jacket with a thermometer.

Another important factor in the study of the soil solution is its concentration because of the effect it has upon the development of the living cell. This concentration concerns the force or pressure that the solutes exert when placed under varying conditions. In connection with the cell, either of the higher or lower plant life with which the soil solution comes in contact the solutes exert a force against the plasma membrane, called osmotic pressure. Here we have three factors to take into consideration—solution, plasma membrane and the solvent. When we have only the solution itself, a single factor, the force that it may exert is called osmotic concentration, usually recorded in pressure of atmospheres. Both the osmotic pressure and osmotic concentration can be determined by the freezing point method.

Before discussing this method of determination, a few words may be said in regard to the effect of solutions upon the living cells. When this solvent, water in the soil solution, passes through the membrane, it causes the liquid to rise or push out the walls of an elastic membrane. In the case of plants, or microorganisms, they become rigid or turgid with this pushing out of their cell walls due to the hydrostatic pressure of the solvent. In order for the cells to take up water, the concentration of the cell sap or cell contents must be greater than that of the soil solution. If the reverse were true, the moisture of the cell would diffuse out. Plasmolysis and ultimately death of the cell would result. In case of plants, this is evidenced by their wilting and finally by their drying. The plants lose their turgidity. The plant nutrients that are in solution diffuse through the cell wall and plasma membrane of the roots as rapidly as the plant utilizes those already in the cell sap. This process is slower than the diffusion of the water. If this water were not replaced either by rain or from some other source, the soil solution would become more concentrated and thus the process would be reversed,—the water going out instead of going in.

NOTE—t and t', = Number of seconds for a given amount of liquid to flow out of apparatus.

The determination of the osmotic pressure is possible directly and indirectly. The former method is tedious and too specific and not adapted to our purposes. Of the indirect, the cryoscopic, or freezing point method of Beckmann was adopted because of its simplicity and reliability. As a complete description of this method can be found in most textbooks on physical chemistry, only a few points will be touched. In our work the thermometer was standardized each day by the freezing of distilled water before and after data were collected on the solution. To prevent any loss of mercury by its rise in the column after removal from the frozen solutions, the thermometer was kept in a tube surrounded by the freezing mixture. It is a well-known fact that solutions freeze at a lower temperature than the solvent itself. The amount of this depression depends upon two factors,—concentration of the substance dissolved and the kind of substance in solution. Two solutions, each containing the same quantity of different substances, will have the same concentration, but their depression of the freezing point will vary on account of the different dissociative properties of the substances in the solution. However, the depression of the freezing point may not give the kind of substance dissolved, but will give an idea of the solution pressure exerted,—whether there is a single substance or a mixture of substances present. Upon this principle of lowering the freezing point is based the determination of the molecular weight and osmotic pressure since both depend upon the concentration of the solution. The figures in the column for osmotic pressure are in degrees, the amount of depression of the freezing point. These can be easily changed to atmospheres by referring to the table in the appendix.

Specific conductivity, the reciprocal of the resistance, is important in that it gives the concentration of the solution, especially the ion concentration, although it does not give any indication as to the presence of colloids or non-electrolytes. The colloids may carry a charge of electricity either as a colloid itself or due to the electrolytes adsorbed by it. The Kohlrausch roller type bridge with a telephone as a detector of the minimum sound given by the induction coil is used for obtaining the resistance of the solution. The current is furnished by a 2-volt storage battery. As the resistance varies according to the area of the electrodes and distance between them, the relation between the area and distance is determined with a known solution of N/50 KC1. This ratio is used for placing the result obtained for the unknown solution upon a comparable basis.

The reaction of the soil is a very important factor both in case of the microorganisms and of the plants. Many times the solution is so colored that it is impossible to use an indicator. The solutions are titrated by the conductivity method. On account of the difficulty of determining the exact neutral point of the ammonium citrate solution by the regular method, Hall and Bell[1], and Patten and Robinson[2] independently applied the conductivity method as a more accurate means of its determination, while Küster and Grüter[3] used this method for finding the end point of a mixture of weak acids and bases and also in colored liquids where it was impossible to use indicators.

[1]Hall, R. A. and Bell, J. M. Physical Properties of Aqueous Solutions Containing Ammonia and Citric Acid. Jour. Am. Chem. Soc. 33, pp. 711-8. 1911.
[2]Patten, A. J. and Robinson. C. S. Neutral Ammonium Citrate Solution. Tech. Bul. No. 12, Mich. Agr. Expt. Sta., 1912.
[3]Küster, F. W. and Grüter, Max. Ueber die Festlegung des Neutralisation punklis durch Leitfähigkeitamessung. 2. Anorg. Chem. 35, p. 454, 1903.

TABLE V.—PHYSICAL ANALYSIS.

A.—Fine sandy soil (surface.)

Laboratory number	Moisture content. Per cent.	Specific gravity.	Specific conduct.	Surface tension.	Osmotic Pressure.	Viscosity.	Total solids.	Inorg. matter.	Org. matter.	Reaction.
18	29.74	1.00166	.000462	1.0223	.02°c.	1.022	700	360	340	Neutral.
18a	22.87	1.00122	.000383	0.9776	.02°c.	1.043	650	370	280	Neutral.
27	40.77	1.00184	.001618	1.0020	.04°c.	1.008	1970	1390	580	Neutral.
(2)	40.77	1.00130	.001557	1.0008	.035°c.	1.016	1980	1420	560	Neutral.
(2a)	40.77	1.00152	.001580	1.0016	.04°c.	1.006	1940	1360	580	Neutral.
28	46.02	1.00084	.001142	0.9517	.02°c.	0.994	1380	810	570	Alkaline.
(2)	46.02	1.00093	.001067	0.9518	.02°c.	0.999	1380	860	580	Alkaline.
29	43.98	1.00099	.001339	0.9519	.02°c.	1.0004	1730	890	840	Alkaline.
(2)	43.98	1.00082	.001353	0.9517	.02°c.	0.999	1620	1030	590	Alkaline.
35	7.66	1.00017	.000254	1.0021	.005°c.	1.0172	399	286	113	Neutral.
(2)	7.66	1.00015	.000257	1.0011	.005°c.	1.0142	400	280	120	Neutral.

B.—Fine sandy soil (subsoil.)

Laboratory number	Moisture content. Per cent.	Specific gravity.	Specific conduct.	Surface tension.	Osmotic Pressure.	Viscosity.	Total solids.	Inorg. matter.	Org. matter.	Reaction.
30	23.18	1.00028	.000860	1.00028	.02°c.	1.0007	520	420	100	Neutral.
(2)	23.18	1.00051	.000709	1.00050	.015°c.	1.00059	660	300	360	Neutral.
32	17.35	1.00095	.001186	1.00295	.03°c.	1.0143	1310	900	410	Alkaline.
(2)	17.35	1.00069	.001170	1.00069	.02°c.	1.0123	1380	950	430	Alkaline.
33	17.71	1.00074	.001122	1.00000	.015°c.	1.0013	1070	540	530	Neutral.
(2)	17.71	1.00077	.001096	1.0028	.015°c.	1.0069	1080	480	600	Neutral.
34	21.08	1.00056	.000887	1.00021	.015°c.	1.0105	933	432	501	....
(2)	21.08	1.00054	.000913	1.00094	.01°c.	1.0093	981	507	474	....

C.—Medium sandy soil (surface.)

Laboratory number	Moisture content. Per cent.	Specific gravity.	Specific conduct.	Surface tension.	Osmotic Pressure.	Viscosity.	Total solids.	Inorg. matter.	Org. matter.	Reaction.
3	24.80	1.0234	.038736	1.0118	1.694°c.	1.116	35880	26080	9800	Neutral.
3a	27.49	1.0231	.035558	1.0141	1.630°c.	1.064	35760	28170	7590	Neutral.

D.—Medium sandy loam (surface.)

Laboratory number	Moisture content. Per cent.	Specific gravity.	Specific conduct.	Surface tension.	Osmotic Pressure.	Viscosity.	Total solids.	Inorg. matter.	Org. matter.	Reaction.
4a	27.24	1.0014	.000771	1.0054	.025°c.	1.0077	980	600	380	Neutral.
17	45.38	1.0015	.006437	1.0475	.015°c.	1.0092	800	620	180	Neutral.

E.—Miami Silt loam (surface.)

Laboratory number.	Moisture content. Per cent.	Specific gravity.	Specific conduct.	Surface tension.	Osmotic Pressure.	Viscosity.	Total solids.	Inorg. matter.	Org. matter.	Reaction.
24	37.81	1.00087	.000361	0.9974	.015°c.	1.0023	1080	680	400	Neutral.
25	36.69	1.00065	.00044	1.0030	.015°c.	1.0023	900	500	400	Neutral.
26	35.12	1.00063	.000503	1.0167	.015°c.	0.9966	700	300	400	....
(2)	35.12	1.00065	.000564	1.0189	.015°c.	0.9986	700	400	300	....
F.—Clyde Clay loam (subsoil.)										
39	54.61	1.00078	.000260	0.9966	.010°c	1.314	960	480	480	Neutral.
42	40.86	1.00013	.000208	0.9998	.006°c.	1.0357	710	460	250	Neutral.
G.—Clyde fine sandy loam (surface.)										
40	43.82	1.000714	.0007199	0.9965	.012°c.	1.0247	1120	720	400	Neutral.
2	40.57	1.000895	.0008972	1.0005	.020°c.	1.091	1320	840	480	Neutral.
41	41.91	1.00126	.0005301	1.00054	.015°c.	1.0025	650	330	320	Neutral.
H.—Miami clay (surface.)										
43	24.52	1.000565	.0002492	1.00056	.013°c.	1.056	260	140	120	Neutral.
I.—Peat.										
22	132.90	1.00136	.001117	1.00037	.02°c.	1.0134	1300	660	640	....
(2)	132.90	1.00130	.001112	1.00037	.02°c.	1.0011	1340	700	640	....
23	251.95	1.00910	.000604	1.00078	.02°c.	0.9902	780	200	580	....
(2)	251.95	1.00687	.000682	1.00075	.02°c.	0.9948	900	200	700	....
J.—Muck.										
20	155.93	1.0008	.000761	1.00580	.02°c.	0.9968	1080	520	560	....
21	164.00	1.0015	.000757	1.00197	.02°c.	0.9994	980	520	460	....

NOTE.—Total solids, inorganic matter and organic matter are expressed in parts per million of the soil solution. Osmotic pressure is given in degrees, which can be easily transferred to pressure of atmosphere by referring to Harris and Gartner's tables in the appendix.

In Table V it should be noted, that 18a, of A as described above was a secondary extraction (p. 515). Since a part of the solution was removed in the first extraction, the results of the second one show a slight lowering in the figures with one or two exceptions but these differences are not marked.

A comparison is also made of the small and large cylinders with the various types of soils. Soils Nos. 27, 28 and 29 of A were from the same source but taken at different times, similarly those of B, E and F were likewise so taken. 3 and 3a were the same at the start but the moistures of the separate portions were made up at different times. The others were obtained at different places.

Taken on the whole the extracts from the two cylinders agree quite closely in nearly all of the determinations. In some the results are closer than those in others. A change in specific gravity produced similar change in specific conductivity and total solids. The change was not so marked in the osmotic pressure or the depression of freezing point on account of a closer reading not being made. Solution 2a of Soil 27 was the portion that came with the oil later. The osmotic pressure in these cases varied in a similar manner as specific gravity, but for some reason or other the total solids were higher.

In the same types of solids, the increase in moisture content causes a decrease in total solids in parts per million. This is noticed in A, B and C. The soils in E were taken from a depression where washings from a sandy loam were deposited, and were taken at different points. These facts may explain why the concentration of its extractions did not follow the above rule. The peat samples also were obtained from two entirely different places. No. 22 contained some washings from the surrounding knolls.

In comparing the results procured from similar soils having different moisture contents, it should be noted that their total solids and also inorganic matter are in a general way inversely proportional to their moisture contents. In most of the cases illustrating the above statement, the ratios are not close due to the fact that the soils were not portions of the same sample and were taken at different times. It is a well known fact that samples taken will vary somewhat in the analytical results. From the entire table, it may be concluded that the concentration of the soil solution varies according to its moisture content. If the moisure content increases, the parts per million of the salts in solution decreases. This does not bear out the conclusions of Whitney and Cameron[1]. They say that "while some variations occur in the composition and concentration of the soil solution, in the case of the great majority of cultivable soils their variations are within comparatively narrow limits. The nature of the solution is but seldom permanently affected by the addition of ordinary mineral fertilizers and it seems safe to say therefore, the concentration with respect to the mineral plant food constituents per unit of solution is approximately constant. Considering the wide variations in the percentages of water present in different soils, however, the amounts of dissolved plant foods in them may be quite different."

[1]Whitney, M. and Cameron, F. K. The Chemistry of the Soil as related to Crop Production. Bul. 22, Bur. of Soils, U. S. Dept. of Agri. (1903) p. 63-4.

TABLE VI.—PHYSICAL ANALYSES OF DIFFERENT PORTIONS OF SOLUTIONS FROM THE SAME SOIL.

Fine sandy soil (subsoil).

Laboratory number.	Total M. in soil.	Portion.	Amount extracted.	Sp. Gravity.	Sp. Conduct.	Parts per million of solution.		
						T. S.	I. M.	O. M.
34 I.	....	1......	538 c. c.	1.000607	0.000863	1260	410	820
	....	2......	450 c. c.	1.000528	0.000889	1030	450	640
	2710	3......	445 c. c.	1.000501	0.000901	790	340	450
	....	4......	167 c. c.	1.000528	0.000928	960	600	360
Total and aver.	....	....	1600 c. c.	1.00056	0.000887	933	432	501
34 II.	....	1......	545 c. c.	1.000607	0.000916	1100	660	440
	....	2......	545 c. c.	1.000490	0.000916	1280	420	860
	....	3......	530 c. c.	1.000528	0.000920	900	390	510
	3828	4......	540 c. c.	1.000560	0.000904	880	540	340
	....	5......	250 c. c.	1.000512	0.000901	780	490	290
	....	6......	225 c. c.	1.000450	0.000904	790	550	240
	....	7......	150 c. c.	1.000560	0.000924	740	450	290
Total and aver.	....	....	2785 c. c.	1.00054	0.000913	981	507	474

Fine sandy soil (surface).

Laboratory number.	Total M. in soil.	Portion.	Amount extracted.	Sp. Gravity.	Sp. Conduct.	T. S.	I. M.	O. M.
35 I.	903	1......	212 c. c.	1.00010	0.000238	380	280	100
	....	2......	103 c. c.	1.00022	0.000255	440	300	140
Total and aver.	....	....	315 c. c.	1.00017	0.000254	399	286	113
35 II.	....	1......	200 c. c.	1.00018	0.000257	440	300	140
	1452	2......	220 c. c.	1.00010	0.000246	350	240	110
	....	3......	95 c. c.	1.00020	0.000274	430	330	100
Total and aver.	....	....	515 c. c.	1.00015	0.000257	400	280	120

I Small cylinder.
II Large cylinder.

In the above two soils, successive portions of the solutions were examined as shown in Table VI. It will be noted that the successive portions do not vary much in specific gravity or specific conductivity, but there is a slight decrease in total solids in Soil 34, while those in Soil 35 remain about the same. The difference here is more in the organic matter (loss in ignition) than in the inorganic matter. This would indicate that part of the total solids was adsorbed. The first portions came from the lower part of the cylinder and the last portion from the upper layers.

TABLE VII.—CHEMICAL PROPERTIES.

A.—Fine sandy soil (surface).

Laboratory number.	Percent moisture.	Parts per million of oven dried soil.								Parts per million of soil solution.							
		K.	PO_4.	Ca.	Mg.	Nitrogen as—				K.	PO_4.	Ca.	Mg.	Nitrogen as—			
						NH_3.	NO_2.	NO_3.	Total.					NH_3.	NO_2.	NO_3.	Total.
18	29.74	7.181	1.542	9.10	....	0.7356	0.0388	0.1374	0.9118	24.15	5.187	30.63	....	2.474	0.1306	0.4620	3.0666
18a	22.87	4.076	1.082	6.75	....	0.3806	0.0058	0.1287	0.5151	17.82	4.687	29.54	....	1.664	0.0254	0.5625	2.2519
28	46.02	20.656	1.726	92.08	51.26	0.2974	0.9668	2.5898	3.8540	47.04	3.750	200.00	111.35	0.647	2.1000	5.6250	8.4720
(2)	46.02	23.020	1.798	65.15	53.29	0.3828	1.4727	2.0708	3.9263	50.00	3.906	141.50	115.75	0.832	3.2000	4.5000	8.5320
29	43.98	27.064	1.727	84.68	42.23	0.2118	1.9775	1.3878	3.5771	61.54	3.884	192.50	96.00	0.4815	4.5000	3.1545	8.1360
(2)	43.98	26.208	2.042	82.86	57.14	0.2421	3.0521	1.1232	4.4174	59.57	4.642	188.35	129.90	0.5503	6.9375	2.5533	10.0378
35	7.66	15.200	0.287	84.04	78.54	0.3322	0.0130	0.2618	0.6070	19.84	3.750	110.25	102.50	0.4335	0.0170	0.3417	0.7922
(2)	7.66	17.012	0.307	78.85	85.32	0.2978	0.0070	0.2902	0.5950	22.20	4.017	102.90	111.35	0.3886	0.0091	0.3788	0.7765
								B.—Fine sandy soil (subsoil.)									
30	23.18	4.166	1.118	12.11	20.83	0.1713	0.2072	0.5479	0.9264	18.00	4.821	52.35	90.00	0.7400	0.8950	2.3670	4.0020
(2)	23.18	5.412	1.241	15.00	22.22	0.1859	0.0025	0.5357	0.7241	23.38	5.357	64.70	96.00	0.8023	0.0110	2.3120	3.1240
32	17.35	4.338	0.944	20.26	19.89	0.1389	0.0000	0.2733	0.4122	25.00	5.442	116.65	114.65	0.8006	0.0000	1.5750	2.3756
(2)	17.35	4.338	0.929	18.37	24.07	0.0599	trace.	2.2439	0.3038	25.00	5.357	105.90	139.75	0.3450	trace.	1.4060	1.7510
33	17.71	10.693	0.709	19.80	17.30	0.1535	0.0096	0.2445	0.4076	60.37	4.014	111.80	98.80	0.8665	0.0540	1.3810	2.5015
(2)	17.71	9.357	0.709	17.71	17.29	0.1868	0.0079	0.2362	0.4309	52.83	4.014	100.04	97.68	1.0550	0.0444	1.3340	2.4334
34	21.08	12.040	0.817	18.91	17.95	0.3121	0.0054	0.3223	0.6399	57.12	3.989	89.75	85.17	1.4805	0.0254	1.5293	3.0352
(2)	21.08	10.220	0.865	23.86	26.24	0.3166	0.0068	0.2914	0.6148	48.48	4.107	113.30	124.48	1.5020	0.0323	1.3823	2.9166
								C.—Medium sandy soil (surface.)									
3	24.80	180.23	1.098	297.36	....	0.936	0.0561	5.9847	6.9768	547.01	3.333	*902.5	....	2.840	0.1703	1.8163	21.1733
3a	29.74	160.88	....	1008.55	563.88	5.760	1.3480	1.1589	8.2669	585.70	....	*3671.75	2052.9	20.971	4.9100	4.219	29.1000

*3—By the turbidity method. 3a—By the gravmetric method. Turbidity method gave 626.35 ppm. of Ca. based on the soil solution.

D.—Medium sandy loam (surface.)

4a	27.24	9.82	1.416	12.748	....	0.1035	0.7900	12.6670	13.5605	36.05	5.2	46.81	....	0.3800	2.90	46.500	49.78
17	45.38	13.23	1.362	8.330	....	0.3822	0.1997	0.5106	1.0925	29.14	3.0	18.35	....	0.8420	0.44	1.125	2.407

TABLE VII.—CHEMICAL PROPERTIES.—*Concluded.*

Laboratory number.	Percent moisture.	Parts per million of oven dried soil.								Parts per million of soil solution.							
		K.	PO_4.	Ca.	Mg.	Nitrogen as—				K.	PO_4.	Ca.	Mg.	Nitrogen as—			
						NH_3.	NO_2.	NO_3.	Total.					NH_3.	NO_2.	NO_3.	Total.
E.—Miami silt loam (surface).																	
24	37.81	27.020	4.642	25.930	....	0.5433	0.0667	0.5984	1.2084	71.11	12.22	68.25	....	1.430	0.1757	1.575	3.1807
25	36.69	20.29	3.946	11.010	....	2.3450	0.0435	0.2551	2.6436	66.48	12.96	36.07	....	7.686	0.1418	0.836	8.6638
26	35.12	9.738	2.798	16.134	....	0.7212	0.0017	0.1481	0.8710	27.76	7.97	45.95	....	2.054	0.0047	0.422	2.4807
(2)	35.12	11.896	2.317	16.134	....	1.4640	0.0017	0.1481	1.6138	33.88	6.61	45.95	....	4.169	0.0047	0.422	4.5957
F.—Clyde clay loam (subsoil).																	
39	54.61	24.13	15.19	....	....	*	trace.	2.664	....	37.85	25.0	....	....	*	trace.	4.179	....
42	40.86	26.18	2.78	31.47	24.41	0.6547	0.0127	trace.	0.6674	64.08	6.8	77.03	59.74	1.6022	0.0313	trace.	1.6335
G.—Clyde fine sandy loam (surface).																	
40	43.82	17.23	2.049	....	....	....	....	....	....	39.33	4.687	....	....	....	....	....	....
(2)	40.57	19.56	1.621	81.03	64.02	0.3492	0.0486	2.0480	2.4458	48.27	4.000	200.0	158.0	0.8620	0.1200	5.0560	6.038
41	41.91	12.44	1.853	37.12	33.43	0.2623	0.0102	3.5347	3.8072	29.71	4.375	88.6	79.8	0.6261	0.0484	8.4375	9.112
H.—Miami clay (surface).																	
43	24.52	11.03	1.13	10.56	32.58	0.2655	0.0074	1.3454	1.6183	44.81	4.6	42.88	132.3	1.0783	0.0300	5.464	6.5727
I.—Peat.																	
22	132.90	94.89	3.360	244.27	....	1.687	0.233	20.80	22.720	50.08	2.528	183.800	....	1.269	0.168	15.65	17.087
(2)	132.90	139.33	2.191	213.70	....	0.935	0.360	31.89	33.195	48.67	1.649	160.825	....	0.704	0.275	24.00	24.979
23	251.95	219.22	39.466	231.55	....	0.580	25.370	143.61	169.570	91.111	15.660	91.900	....	2.303	8.000	57.00	67.303
(2)	251.95	293.20	38.674	244.50	....	3.416	20.160	182.90	206.510	116.666	15.450	97.030	....	1.356	8.000	72.60	81.956
J.—Muck.																	
20	155.01	85.91	3.573	90.14	....	0.7446	0.6454	18.79	20.18	60.11	2.500	63.07	....	0.521	0.4516	13.15	14.1226
21	164.00	146.57	4.052	188.79	....	2.1290	0.5583	35.17	37.86	100.00	2.765	125.89	....	1.453	0.3809	24.00	25.8339

*Not determined—lack of solution.

Chemical.

The mineral constituents studied were those that were of some use to the plant as K, PO_4, Ca, (Mg in later determinations) and N in the forms of ammonia, nitrite and nitrates. The results are given both as parts per million (p.p.m.) of the solution and of oven dried soil. As the soil varied in moisture content, the latter puts the results on a more comparable basis.

The above nutrients were determined by the method as found in Bulletin 31, Bureau of Soils, for colorimetric work. Finding it difficult to obtain good results for calcium by this method, gravimetric determinations of calcium and magnesium were then made according to Bulletin 107, (pp. 15-16) Bureau of Chemistry. The phosphoric acid (PO_4) with a few exceptions is not high. Most of the results lie between one and five parts per million on oven dried soil. The potash (K) has a wider variance than that of phosphoric acid. The calcium and magnesium vary considerably in the different soils, due to the treatment and reaction of the soil.

The nitrogen varies, but this is to be expected since it is a more changeable quantity. The solutions from the same soil extracted at the same time, one from a small cylinder and the other from the larger one, agree fairly well in most of the cases in total nitrogen (sum of the different kinds), whereas they may vary in the ammoniacal nitrate or nitrate nitrogen. This is due probably to denitrification taking place in the cylinders during the extractions. This was noted in an extraction of a sandy soil. No. 32 of B. No nitrite was found in the solution from the small cylinder and only a trace in the larger one, but the portions that came with oil afterwards showed marked amount of nitrogen present as nitrite. This led to the analyzing of successive portions.

TABLE VIII.—NITROGEN DETERMINATION OF DIFFERENT PORTIONS OF THE SAME SOIL.

Amount of N. in various portions of extractions of a sandy soil.

Laboratory number.	Portion.	Parts per million of soil solution. Nitrogen as—			
		Nh_3.	No_2.	No_3.	Total N.
34 I.	1	1.5528	Trace.	1.6875	3.2403
	2	1.5528	0.0108	1.5000	3.0636
	3	1.2930	0.0430	1.4800	2.8160
	4	1.5528	0.1000	1.2300	2.8828
34 II.	1	1.5528	mere trace.	1.712	3.264
	2	1.5528	slight trace.	1.514	3.066
	3	1.5528	slight trace.	1.406	2.958
	4	1.5528	0.015	1.334	2.901
	5	1.5528	0.055	1.125	2.732
	6	1.0352	0.100	1.044	2.179
	7	1.3860	0.239	0.868	2.493
35 I.	1	0.5127	0.0110	0.3438	0.8675
	2	0.2717	0.0291	0.3375	0.6383
35 II.	1	0.5435	0.0062	0.3438	0.8935
	2	0.2929	0.0107	0.3938	0.6984
	3	0.2717	0.0112	0.4183	0.7012

I Small cylinder.
II Large cylinder.

In Table VIII it will be noted in Soil 34 that the nitrogen as ammonia remains the same with one or two exceptions, but in Soil 35 there is a decrease. In all cases the nitrogen as nitrite increased while the nitrate decreased, with the exception of 35 II where it increased. The change in this case was between ammoniacal nitrogen and nitrate nitrogen. In nearly all cases there was a very slight decrease in the total nitrogen (sum of the different forms of nitrogen) in the successive portions of soil solution.

Biological.

Only a very small percentage of the bacteria are removed from the soil since the soil in the cylinder acts as a filter in holding back most of the suspended substances. The soil acts on the same principle as a filter bed in a water purification plant. If the cylinders are allowed to stand too long a very marked anaerobic decomposition takes place which is quite marked in clay soils or those with considerable organic matter as evidenced by the disagreeable odor given off. In Table VIII there will be noted a slight denitrification,—less nitrates and more nitrites. This is especially true in 34 I and II, and 35 I.

This soil solution is now being used in connection with the study of the microbial decomposition of nitrogenous compounds in the soil. Favorable progress has been made. Mr. O. M. Gruzit, in this laboratory, has used the soil solution to study the effect of some acids, alkalis and inorganic salts upon soil bacteria and has found some interesting results. A report on the results of these investigations is now being prepared for publication.

SUMMARY.

Soil solution is a homogeneous mixture of water (solvent) and the soluble ingredients of the soil (solutes.)

The water itself does not bring into solution all the solutes it contains without the aid of some of the substances that have been already dissolved.

The study of the soil solution is of a great importance because this solution plays an important role in soil changes or transformations, and because it furnishes a medium for plant and microbial growth.

Drainage waters contain too much of some ingredients and too little of others to give any definite information as to the soil requirements.

Soil extracts contain more of some ingredients, and also other ingredients, than are generally present in the natural soil solution readily available for the plant. This is due to the action of the acids, water, etc., used in making the extracts.

The artificial root is applicable to those soils of high moisture content and furnishes only a small amount of solution.

The centrifuge does not furnish sufficient amount of solution for any extensive study.

Schloesing's and also Gola's method are not applicable to soils having a low moisture content, while Istcherikov's method can be applied to soils of low moisture content, but is objectionable because alcohol has a solvent action on some of the soil particles.

A thick viscous cylinder oil was used in making the extractions.

The paraffin oil pressure method furnishes in most cases plenty of solution for the necessary analytical work. In sandy soils as high as 74 per cent of the moisture present in the soil was obtained.

A large amount of solution may be obtained without coming in contact with the oil. If it does it can be easily separated by cooling and separatory funnel.

The concentration of the soil solution from the same type of soil varies according to the moisture content of that soil from which it is derived.

Successive portions of the same extraction vary very little in their physical properties, but do more in the various forms of nitrogen.

The forms of nitrogen vary in the different solutions, since they are changeable quantities. Calcium and magnesium also vary due to the treatment and reaction of the soil. The phosphoric acid (PO_4) is fairly constant. Potash (K) varies somewhat.

A small percentage of the bacteria are removed from the soil, since the soil acts as a filter.

Anaerobic changes take place in the cylinder if it is allowed to stand for a long time.

The paraffin oil displacement-pressure method furnishes as far as we are able to judge with our present facilities, a fair representative of the solution as it exists in the soil. The method permits the use of a large amount of soil thus a better representative sample. Work now in progress indicates that it furnishes a valuable index of the microbial changes in the soil.

POSSIBILITIES AND LIMITATIONS.

The soil solution is important from the plant physiologist's point of view for the study of plant nutrients and balanced solutions. It opens a field for the soil chemist and physicist for the study of some of the soil conditions,—e. g., composition and concentration of the liquid phase of the soil. To the soil bacteriologist it is important for the study of microbial changes that take place in the soil, the filterable microorganisms in the soil and of pathogenic microorganisms that may live in the soil.

The method has its limitations in that the oil does not penetrate all soils and, therefore, does not give all the soil solution that might be otherwise obtained.

The amount of solution obtainable depends upon the moisture content of the soil and upon the type of soil. The greater the moisture content, the greater the amount of solution that can be obtained from the various samples of similar soils. From samples of dissimilar soils having equal moisture content, the proportion of the total moisture removable varies with the soil type, the largest percentage being obtainable from sandy soils and the smallest from clay soils.

The method is still open for improvement. Certain phases of it need further study, as the type of cylinder, displacing liquid, and the method of packing the soil in the cylinder.

Type of cylinder—The size of the cylinder is important in obtaining the best results as has been shown with a few extractions described

above. The effect of the diameter in proportion to its length is worthy of consideration.

Displacing liquid—Some other liquid might be found that will penetrate all soils and still have no action upon the solution chemically or physically.

Packing—Some method needs to be devised that will give a more uniform packing so that the displacing liquid will give better results.

APPENDIX.

Table of Osmotic pressures in atmospheres for depression of the freezing point to 2.999°C. Harris and Gortner)[1].

	Hundredths of degrees, centigrade.									
	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0.0	0.000	0.121	0.241	0.362	0.482	0.603	0.724	0.841	0.965	1.085
0.1	1.206	1.327	1.447	1.568	1.688	1.809	1.930	2.050	2.171	2.291
0.2	2.412	2.532	2.652	2.772	2.893	3.014	3.134	3.255	3.375	3.496
0.3	3.616	3.737	3.857	3.978	4.098	4.219	4.339	4.459	4.580	4.700
0.4	4.821	4.941	5.062	5.182	5.302	5.423	5.543	5.661	5.784	5.904
0.5	6.025	6.145	6.266	6.386	6.506	6.627	6.747	6.867	6.988	7.108
0.6	7.229	7.349	7.469	7.590	7.710	7.830	7.951	8.071	8.191	8.312
0.7	8.432	8.552	8.672	8.793	8.913	9.033	9.151	9.274	9.394	9.514
0.8	9.635	9.755	9.875	9.995	10.12	10.24	10.36	10.48	10 60	10.72
0.9	10.84	10.96	11.08	11.20	11.32	11.44	11.56	11.68	11.80	11.92
1.0	12.04	12.16	12.28	12.40	12.52	12.64	12.76	12.88	13.00	13.12
1.1	13.24	13.36	13.48	13.60	13.72	13.84	13.96	14.08	14.20	14.32
1.2	14.44	14.56	14.68	14.80	14.92	15.04	15.16	15.28	15.40	15.52
1.3	15.64	15.76	15.88	16.00	16.12	16.24	16.36	16.48	16.60	16.72
1.4	16.84	16.96	17.08	17.20	17.32	17.44	17.56	17.68	17.80	17.92
1.5	18.04	18.16	18.28	18.40	18.52	18.64	18.76	18.88	19.00	19.12
1.6	19.24	19.36	19.48	19.60	19.72	19.84	19.96	20.08	20.20	20.32
1.7	20.44	20.56	20.68	20.80	20.92	21.04	21.16	21.28	21.40	21.52
1.8	21.64	21.76	21.88	22.00	22.12	22.24	22.36	22.48	22.60	22.72
1.9	22.84	22.96	23.08	23.20	23.32	23.44	23.56	23.68	23.80	23.92
2.0	24.04	24.16	24.28	24.40	24.52	24.63	24.75	24.87	24.99	25.11
2.1	25.23	25.35	25.47	25.59	25.71	25.83	25.95	26.07	26.19	26.31
2.2	26.43	26.55	26.67	26.79	26.91	27.03	27.15	27.27	27.39	27.51
2.3	27.63	27.75	27.87	27.99	28.11	28.23	28.34	28.46	28.58	28.70
2.4	28.82	28.94	29.09	29.18	29.30	29.42	29.54	29.66	29.78	29.90
2.5	30.02	30.14	30.26	30.38	30.50	30.62	30.74	30.86	30.88	31.09
2.6	31.21	31.33	31.45	31.57	31.69	31.81	31.93	32.05	32.17	32.29
2.7	32.41	32.53	32.65	32.77	32.89	33.00	33.13	33.25	33.36	33.48
2.8	33.60	33.72	33.84	33.96	34.08	34.20	34.31	34.43	34.56	34.68
2.9	34.79	34.91	35.04	35.16	35.27	35.39	35.51	35.63	35.75	35.87

[1]Harris and Gortner. American Journal of Botany, I, 75-78.

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FOREWORD.

TECHNICAL BULLETIN NO. 29.

The results herein recorded are based on the data that were presented by the junior author in 1915 as a portion of a thesis for the degree of Master of Science at this institution. The senior author is responsible for directing the work and for preparing the results for publication. These studies form a part of the general attack on the subject of "Keeping Qualities of Butter" which has been under investigation for a number of years and is still being considered in this laboratory.

WARD GILTNER.

KEEPING QUALITIES OF BUTTER.

IV. CREAM RIPENING AND ITS INFLUENCE. (CONTRIBUTION).

BACTERIA IN CREAM, THEIR NUMBERS AND TYPES AND THEIR ITINERARY IN THE MANUFACTURE OF BUTTER.

CHAS. W. BROWN AND KURT PEISER.

INTRODUCTION.

Modern students of butter constantly are paying more attention to the methods of handling and to the condition of the raw products, the milk and the cream prior to its receipt at the creamery, as influencing markedly or even predetermining the quality and life of the butter. Cream produced under the usual conditions frequently contains a large number of bacteria which comprise a number of species from various sources. Many of these species find conditions favorable for growth and as a result multiply more or less rapidly. By far the larger number of the bacteria in milk are admitted from external sources and it is due to the presence and growth of these that milk is caused to change in taste and odor and to undergo the processes of souring and decomposition. A large number of each of the different types present in the milk is carried over with the cream during separation. Many of these types cause the same changes in cream as in milk, some discriminate and others are indifferent. The difficulties and problems involved in the handling of cream for the manufacture of butter are so numerous and complex that a uniformity in the finished product is not easily attained. Creamerymen realize that butter of the best quality cannot be made from cream that is produced under unsanitary and neglectful conditions. The destruction of the natural, sweet, rich flavor of cream through the carelessness of the producer and through the neglect of the cream is manifest in the butter.

PURPOSE.

This paper deals with the bacteria in cream relative to the numerical count and prevailing types and traces these types through the different steps in the manufacture of butter.

LITERATURE REVIEW.

In this review we have in mind the source and number of microorganisms in cream and butter and their effect upon these products. The microorganisms of milk are the microorganisms of cream. That the bacteria in milk are concentrated in the cream during their passage through the separator is expressed by Stocking on page 318 of Marshall's Microbiology; the same has been demonstrated by the work of this laboratory. This indicates that the types of organisms present in the milk are also present in the separated cream. Evans (4) states that *Bact. abortus* is an organism infecting cream and that in whole milk an abundant growth occurs in the cream layer. The first possible source of bacteria in milk is from the interior of the udder. Harding and Wilson (6) state that an average of 500 bacteria per c.c. can be ascribed as being in the milk when it is drawn. They find, in their study of fifteen udders,.71 groups of miscoorganisms which are mostly micrococci. The most common organisms of the udder were found to be *Micrococcus lactis albidus* and *Micrococcus lactis varians.* In one udder a non-liquefying yeast was found in rather large numbers. About 30 per cent of these types of microorganisms are slow liquefiers and the greater number of the remainder are indifferent to milk. Hastings and Hoffman (8) found in the milk of two cows throughout the lactation periods an average of 38,800 and of 30,700 bacteria per cubic centimeter respectively. These organisms were streptococci, very similar in cultural and biochemical features to *Streptococcus pyogenes,* yet no gargety condition of the udder was present during these investigations. These authors conclude that the same organism may not only persist in the udder of a cow for long periods but may be present constantly in large numbers. Esten and Mason (3) made a bacterial study of material such as "curry powder," cow feces, hay, grass, ground feeds, soil, barn air, flies, etc., which might gain access to milk thus forming a source of contamination. On all of these materials microorganisms comprising a number of types were found. Many of these from marked changes in milk and in the products obtained and manufactured therefrom. In studying the source of *Bact. lactis acidi* Esten (2) concludes that the cow's mouth is a natural habitat and that any object or material reached by the tongue or saliva of the cow is well stocked with this bacterium. From these various materials it enters milk where it is found almost constantly. Occasionally this bacterium is found in the udder (3, p. 78), the presence of which can be accounted for in many cases by the contamination of the teats with the saliva of a suckling calf (6, p. 38). *Bact. lactis acidi* not being influenced by the germicidal properties of milk (15, pp. 15 and 20) increase in numbers from the very start. Gas producing bacteria, normal inhabitants of the alimentary tract, may be found in large numbers on objects and materials which have been contaminated with fecal matter. In a few instances members of this group of organisms have been found in the udder (7, p. 3). From these sources, directly or indirectly, nearly all milk is well supplied with gas producing bacteria (7, p. 2) which multiply rapidly. Lewis and Wright (9, pp. 8-9) found

that in summer a large percentage of the samples of cream analyzed contained as many as 100,000 gas producing bacteria per cubic centimeter. By inoculating pasteurized cream with gas producing bacteria, Harrison (7, p. 7) observes that the butter had a bitter, disagreeable and astringent flavor and concludes that these organisms are as injurious to the flavor of butter as they are to the flavor of cheese. The group of anaerobic sporebearing gas producers (*B. enteritidis sporogenes,*) or *B. welchii*) which are interesting because they sometimes cause intestinal disturbances and are indicators of manurial pollution, are found to be present in small numbers in milk and cream, but from the work of Rosenau, Frost and Bryant (13), *enteritidis* spores are not found in butter although their presence in the cream was demonstrated. Liquefying bacteria which are numerous in soil and on feeds (3) find their way in large numbers into milk (15, p. 18) and from thence to cream (9, pp. 10 and 11). Ayers and Johnson (1, p. 59) find that the relative proportion of the groups of peptonizing and lactic acid bacteria is approximately the same in efficiency pasteurized milk as it is in clean raw milk; the percentage of liquefiers (1, pp. 79-82 and 90-92) range about 5 to 25 per cent, and of the acid producers about 30 to 70 per cent of the total flora. For continuous pasteurization of cream a temperature between 74° C. and 80° C. is recommended by Rogers, Berg and Davis (11, pp. 310 and 326) who show that from 99.7 per cent to 99.9 percent of the total flora is killed. Also they conclude from their results that the catalase and the lipase in milk are destroyed at 70° C., peroxidase at 77° C. and that galactase is not destroyed at 93° C. Data given by Rogers, Berg, Potteiger and Davis (12, p. 33) show the number of bacteria in cream from a skimming station to be approximately 50,000,000 per cubic centimeter which they group as acid formers about 26.5 percent, as alkali formers about 4 percent, as peptonizers about 6.5 percent and as inert about 53 percent. The total number of microorgaisms in sour cream as it arrived at the creamery was found by Hammer (5, pp. 37-40) to be in the hundred millions; and pasteurization at 63° C. for 20 minutes and at 83° C. by the flash method gives approximately the same results, i. e., 99.99 percent efficiency. As a result of a series of analyses by Sayer, Rahn, and Farrand (14, pp. 28-45) various types of microorganisms are found in butter; *Bact. lactis acidi* was omnipresent, a small irregular yeast was present in most samples and *Micrococcus lactis varians,* an organism present in many udders, was found frequently. Rahn, Brown and Smith (10, pp. 35-40) gives data showing that liquefying and nonliquefying torulae and *Oöspora lactis* (*Oidium*) are present in butter frequently and sometimes in rather large numbers.

While the literature cited on this subject is by no means exhaustive and while it is admitted that other data fully as conclusive have not been mentioned, yet it is believed that this review will serve amply as an introduction to the subject.

INVESTIGATIONAL WORK.

This work was carried out under commercial conditions and the data should represent the numerical numbers of bacteria and include the most prevalent types of organisms present at different stages in the manufacture of butter.

METHODS.

Source of Cream. Cream was obtained from dairymen in the vicinity of the College.

Taking Samples. Samples (about 50 cc. each) of cream, pasteurized cream, starter, ripened cream and buttermilk, were taken with sterile pipettes and introduced into sterile 100 cc. Erlenmeyer flasks. Analyses of these samples were made immediately after collection. Four samples of butter (about 100 grams each), one before washing and salting and three when the butter was ready to tub, were taken from the churn under aseptic conditions and placed in sterile deep culture dishes. The sample taken before salting and one of the samples taken after were analyzed at once, the other two were stored at 40° to 45° F. in a dark room and examined after seven days and one month respectively.

Bacterial Content and Isolation. In all steps except those concerning butter, 1 cc. of the medium was added to 99 cc. of sterile physiological salt solution. The mixture then was shaken and other dilutions made by introducing 1 cc. of this into another 99 cc. of sterile salt solution. Dilutions of 1:1,000, 1:10,000, 1:100,000 and 1:1,000,000 were then plated in litmus lactose agar and duplicate dilutions in casein agar. Butter was introduced into a small Erlenmeyer flask and placed in a water bath at 35° C. until the butter had softened, then the flask was shaken to insure uniformity. One gram (1.15 c.c.) was measured by means of a sterile pipette and introduced into 99 c.c. of warm (35° to 40° C.) sterile salt solution. This was shaken to a milky emulsion and higher dilutions were made as above. Samples were plated in litmus lactose agar and in casein agar, the same dilutions were used as for cream. All plates were incubated at 20° to 22° C. After bacterial counts were recorded many of the organisms were isolated and transferred from the agar plates to sterile nutrient bouillon.

Litmus lactose agar used for plating was made according to the rules adopted for nutrient agar by the Committee on Standard methods (Jour. Inf. Dis. Suppl. No. 1. 1905) to which 1 percent lactose and 0.003 percent azolitmin was added.

Casein agar was made up according to the formula given by S. H. Ayers in the 28th Annual Report of the Bureau of Animal Industry.

Peroxidase. The presence of peroxidase was determined by the gum guaiac test. A tincture of guaiac was made by dissolving a little of the powdered resin in alcohol. About 10 c.c. of the sample was placed in a test tube shaken with a few drops of hydrogen peroxide, then two drops of guaiac tincture were allowed to run down the sides of the tube coming in contact with the sample but not being mixed with it. The appearance of a blue ring within a few minutes is considered positive for *peroxidase*.

Reductase. The presence of reductase was determined by adding 1

c.c. of Schardinger's solution (190 c.c. of distilled water, 5 c.c. formalin and 5 c.c. of saturated alcoholic methylene blue) to 10 c.c. of the medium to be tested, the reagent and milk were shaken to mix uniformly and placed in a waterbath at 37° C. for half an hour. Decolorization of the methylene is recorded as reductase positive.

Moisture. The moisture was determined by heating 10 gms. of butter in an aluminum cup according to the Ames test. The sample was reweighed and the percent of moisture obtained by multiplying the loss in weight by 10.

Salt. The amount of salt was determined by a slight modification of the Shaw test, the silver nitrate reagent is of such strength that 1 c.c. represent 0.001 grm. of salt or 0.1 percent when a 1 gm. sample is used, potassium chromate is used as an indicator.

Acidity. This determination was made by diluting 10 c.c. of the sample with distilled water and titrating with N/10 NaOH (the samples of butter were dissolved in a mixture of equal parts of alcohol and ether and not diluted with distilled water (See 10, p. 12) and recorded as cubic centimeters of N/10 acid per 100 grms.

Fat. The percent of fat present was determined by the Babcock test.

Spores of anaerobic gas producers. The presence of spores of anaerobic gas-producers was tested for in every step of butter manufacture in the following way: the medium to be examined was placed in sterile test tubes; 1 c.c. in the first, 4 c.c. in the second, 8 c.c. in the third and 12 c.c. in the fourth tube. Enough sterile milk was added to the first three tubes to make the contents of each approximately 12 c.c. The tubes were heated in a water bath at 80° C. for ten minutes, cooled and the medium covered with one-half to three-quarters of an inch of sterile liquid paraffin to exclude the air. The tubes were incubated at 37° C. for two days. An abundant production of gas, the cream being disturbed and often thrown to the surface of the paraffin oil and coagulated masses of casein were recorded positive for spores of this group.

Coli-aerogenes group. The presence of this group was determined by the inverted vial method, 1 c.c., 0.5 c.c., dilutions of 1:10, 1:100, and 1:1,000 of the sample was used. The production of gas in dextrose broth was considered positive. No attempt was made in this work to determine the presence of yeasts.

Peptonizers. To determine the number of peptonizing microorganisms (colonies), the casein agar plates, after counts were recorded, were flooded with N/10 lactic acid. The action of the lactic acid is to precipitate the dissolved casein which produces an opaque, white medium with the exception of a clear zone around the colonies which have hydrolyzed the casein. Colonies surrounded by a clear zone and thus set off from the rest of the solid white medium are considered peptonizers.

Acid Organisms. The lactic acid bacteria were determined by direct count on litmus lactose agar plates. They form either a distinct boat-shaped or a round colony which is small and of a distinct pinkish-red color. This does not include members of the coli-aerogenes or of the bulgaricum group. No attempt was made to determine the numbers of *Bact. bulgaricum* present in cream or butter.

Inert and Indifferent Organisms. Every microorganism that made a visible colony on either the litmus lactose agar or the casein agar and that was not counted as a gas-producer, as a peptonizer or as an acid-producer is grouped under this head.

TABLE I.—DATA OBTAINED FROM TWELVE CHURNINGS.

(Including cream, starter, buttermilk and butter.)

Sample.	Number of churning.											
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Butterfat and salt (percent):												
Cream	31.5	36.3	32.1	30.2	33.2	29.1	27.4	32.5	31.2	30.1	31.4	29.4
Butter	3.3	3.1	3.0	3.4	2.9	3.1	3.1	3.3	3.2	3.0	3.1	3.2
Moisture (percent):												
Butter (unwashed)	14.1	13.9	14.6	15.2	14.3	14.6	14.2	14.3	15.1	14.4	14.6	15.2
Butter	14.1	14.3	14.9	14.2	14.6	15.1	14.3	14.1	14.6	14.2	14.7	14.4
Butter (7 days)	14.0	14.2	14.7	14.1	14.4	14.9	14.1	13.9	14.2	14.1	15.5	14.3
Butter (30 days)	14.0	14.1	14.7	14.1	14.6	15.0	14.1	14.0	14.2	14.1	14.3	14.2
Acidity (percent of N-10 acid):												
Cream	52	49	51	53	47	49	53	48	51	49	51	52
Pasteurized cream	51	47	50	52	46	47	51	47	50	47	50	50
Starter	71	69	74	72	68	69	71	73	68	71	72	69
Ripened cream	53	54	59	53	51	56	49	57	52	58	56	55
Buttermilk	67	65	71	65	66	67	64	69	67	69	63	65
Butter (unwashed)	20.0	20.1	20.3	19.2	20.2	19.8	21.0	20.6	20.0	20.3	20.6	20.1
Butter	21.0	20.1	21.3	20.6	20.7	21.2	19.8	21.4	22.0	21.0	20.4	20.6
Butter (7 days)	20.9	20.0	21.3	20.5	20.7	21.2	19.8	21.7	22.0	21.0	20.4	20.6
Butter (30 days)	20.9	20.0	21.3	20.7	20.8	21.2	19.8	21.4	22.0	21.4	20.6	20.4
Bacterial count on litmus lactose agar. (Numbers represent millions per gram):												
Cream	3,540*	4,930*	3,643*	4,140*	3,810*	2,941*	4,103*	2,714*	3,213*	2,914*	3,425*	2,734*
Pasteurized cream	85*	74*	69*	63*	72*	75*	79*	81*	64*	71*	67*	68*
Starter	1,927	1,132	1,324	964	1,743	1,541	1,231	1,719	1,427	1,312	1,243	973
Ripened cream	439	571	490	563	714	439	532	621	592	466	512	610
Buttermilk	452	531	476	431	336	531	446	571	382	361	324	538
Butter (unwashed)	146	121	96	156	143	132	87	198	137	124	173	104
Butter	56	63	71	52	46	61	59	67	54	49	61	48
Butter (7 days)	43	47	46	35	32	44	31	52	43	41	51	40
Butter (30 days)	29	31	19	14	27	21	23	24	29	34	38	21
Bacterial count on casein agar. (Numbers represent millions per gram):												
Cream	3,124*	3,982*	3,234*	3,742*	3,712*	3,713*	3,614*	3,144*	3,712*	3,214*	2,913*	3,147*
Pasteurized cream	86*	63*	71*	74*	62*	69*	74*	77*	69*	65*	64*	67*
Starter	1,324	962	1,431	1,241	1,322	1,124	926	1,421	1,131	1,024	981	924
Ripened cream	421	527	463	541	702	511	663	581	526	502	582	571
Buttermilk	391	476	512	476	391	482	461	496	432	412	386	381
Butter (unwashed)	127	134	112	131	114	152	119	174	163	146	124	116
Butter	47	56	63	44	51	57	54	64	52	51	54	43
Butter (7 days)	41	32	43	31	37	41	29	45	39	29	48	34
Butter (30 days)	27	28	21	13	32	19	31	21	23	29	34	27
Bact. lactis acidi type. (Percent of total flora):												
Cream	32	29	31	32	27	34	29	31	35	32	31	29
Pasteurized cream	48	51	62	53	48	56	43	49	52	47	54	59
Ripened cream	96	98	97	95	96	97	95	98	96	95	97	98
Buttermilk	81	83	74	71	86	81	76	84	63	85	71	82
Butter (unwashed)	69	64	78	83	81	79	69	71	87	76	64	69
Butter	74	78	81	72	74	79	74	63	81	72	84	68
Butter (7 days)	67	61	68	65	63	59	68	63	64	78	62	69
Butter (30 days)	62	54	58	64	72	51	63	57	51	56	59	63

TABLE I.—DATA OBTAINED FROM TWELVE CHURNINGS.—*Concluded.*

Sample.	Number of churning.											
	1.	2.	3.	4.	5.	6.	7.	8.	9.	15.	11.	12.
Gas-producers and peptonizers. (Percent of total flora):												
Cream	43	41	36	41	45	41	44	43	29	37	46	49
Pasteurized cream	12	15	11	14	9	12	17	14	12	16	13	12
Ripened cream	3	1	2	3	1	2	3	1	3	3	2	1
Buttermilk	8	9	17	15	12	11	14	8	21	9	19	10
Butter (unwashed)	23	29	16	9	12	13	23	18	9	16	27	18
Butter	11	9	12	17	14	11	15	17	8	11	13	12
Butter (7 days)	13	17	15	18	14	16	16	16	18	8	14	15
Butter (30 days)	17	19	18	17	19	23	11	17	22	21	17	18
Inert or indifferent group. (Percent of total flora).												
Cream	25	30	23	27	28	25	27	26	36	31	23	22
Pasteurized cream	40	34	27	33	43	32	40	37	36	37	33	29
Ripened cream	1	1	1	2	3	1	2	1	1	2	1	1
Buttermilk	11	8	9	16	2	8	10	6	16	6	10	8
Butter (unwashed)	8	7	6	8	7	8	8	11	4	10	9	13
Butter	15	13	7	11	12	10	11	20	11	11	3	20
Butter (7 days)	20	22	17	19	21	25	16	21	18	14	24	16
Butter (30 days)	21	27	24	19	9	26	23	24	27	23	24	19

*These numbers represent thousands per gram.

TABLE 2.—AVERAGE OF DATA OBTAINED FROM TWELVE CHURNINGS.

Sample.	Acidity per cent (N/10.)	Total bacterial count per gram.	Bact. lactis acidi type per cent (of total).	Gas-producers and peptonizers per cent (of total).	Indifferent group per cent (of total).	Coliaerogenes group.	Presence of		
							B. enteritidis sporogenes spores.	Peroxidase.	Reductase.
Cream	48	3,640,000	32	43	25	+	+	+	+
Pasteurized cream	47	72,000	53	14	33	+	+	+	+
Starter	71	1,427,000,000	100	....	....	−	−	−	−
Ripened cream	56	520,000,000	95	3	2	+	+	−	−
Buttermilk	66	461,000,000	83	11	6	+	+	−	−
Butter (unwashed)	20.1	122,000,000	78	13	9	−	−	+	+
Butter	20.2	56,000,000	76	11	13	−	−	+	+
Butter (7 days)	20 0	39,000,000	63	16	21	−	−	+	+
Butter (30 days)	20.1	26,000,000	58	19	23	−	−	+	+

PEROXIDASE AND REDUCTASE IN CREAM AND BUTTER.

When the various samples were analyzed, tests were made for the presence of the enzymes peroxidase and reductase. The data recorded in Table II show that these enzymes reacted negatively when starter, ripened cream or butter milk was the sample in question. The unripened cream and the butter manufactured therefrom reacted positive. Their presence in the butter indicate that they were not destroyed but rather that they were inactivated during the ripening process. As the difference between the unripened and ripened cream is manifested in the acidity, samples of cream which react positive for both of these enzymes were made 0.55 percent acid by adding N/1 lactic acid; these acidified samples reacted negative, but upon reducing the acidity of duplicate samples by the addition of N/1 sodium hydroxid positive tests were ob-

tained. We attribute the positive tests in butter to the lower acidity and not to the formation of new enzymes; and the negative test in starter to the high acidity—in fact starter, when the acid is neutralized, reacts strongly positive to the reductase test.

ACIDITY OF CREAM AND BUTTER.

The acidity of the cream during the ripening process is constantly changing (Fig. 1). Our cream which on an average had about 30 per cent fat contained an average of 0.43 percent acid. This means that the cream was not in need of a further development in acidity, but as a control measure starter was added a few hours before churning. The acidity of the ripened cream averaged 0.50 percent which is too high for the

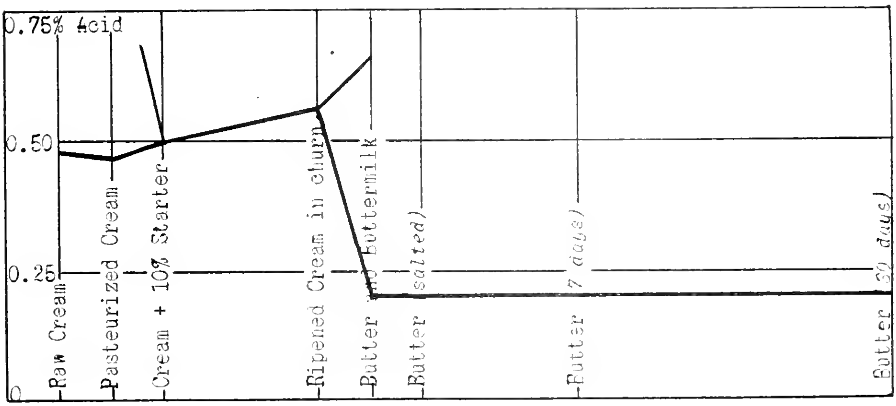

Fig. 1. *Graphic representation of changes in acidity (average of twelve churnings) at different steps in the manufacture of butter.*

NOTE.—The graduations on the vertical line in Fig. 1 should read 25, 50 and 75 per cent N/10 acid respectively.

best results in the stability of the product. The acidity (average of 20 per cent N/10) of the butter from the time of drawing the buttermilk to thirty days later remained almost constant.

ADAPTATION OF CASEIN AGAR AND LITMUS LACTOSE AGAR FOR NUMERICAL AND DIFFERENTIAL COUNT.

Throughout this work the total counts on each of the two media were very close together, the count on the casein agar generally was a little lower. Each medium has its advantages and disadvantages. On the casein agar the bacteria did not grow so rapidly, but the inert, the alkali forming and the peptonizing groups were favored. This medium is valuable for the detection of peptonizers. The litmus lactose agar lends itself admirably to the enumeration and isolation of acid-producing bacteria.

TYPES AND NUMBERS OF MICROORGANISMS IN CREAM AND BUTTER AS INFLUENCED BY THE MANIPULATIONS OF THE CREAM DURING THE MANUFACTURE OF BUTTER.

In this study we have for convenience grouped the microorganisms in three groups: First, bacteria of the starter type; second, gas-producers (coli-aerogenes and anaerobic gas-producers) and the casein liquefiers; and third, bacteria which are inert or indifferent in milk.

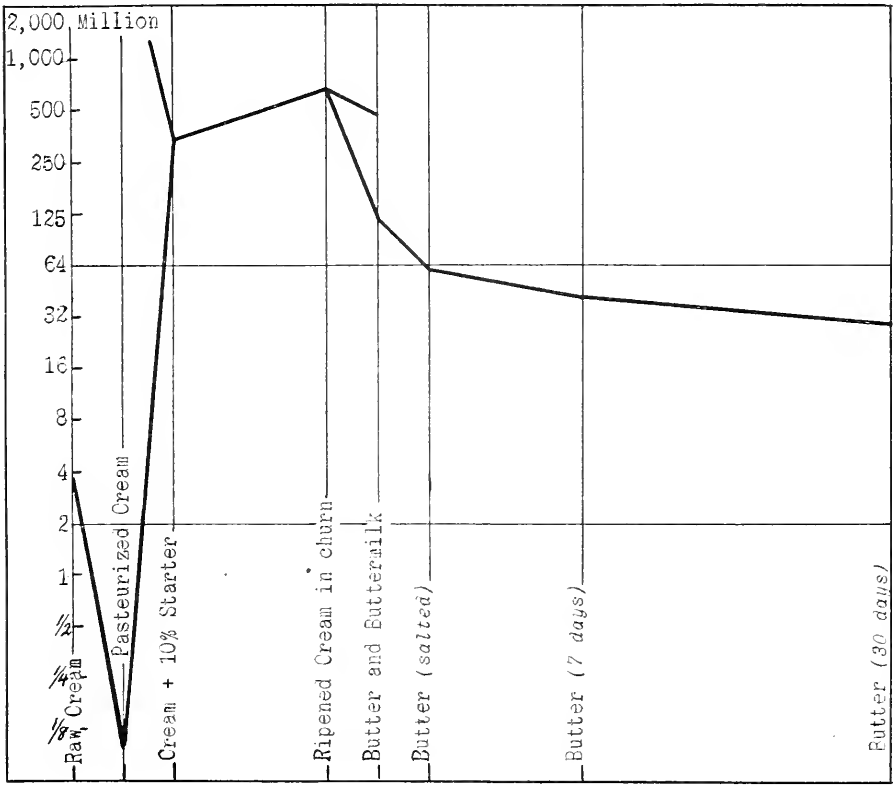

Fig. 2. *Graphic representation, based on the log of "2", of the total number of microorganisms (average of twelve churnings) present at different steps in the manufacture of butter.*

The total number of bacteria found at different periods in the manufacture of butter is represented graphically in "Fig. 2." Pasteurization kills a large percentage, the addition of starter adds enormous numbers, an increase is noticed during the period of ripening and at the time of churning a marked decrease in the number of living bacteria is observed. Neither the butter nor the buttermilk from the churn contains as many living bacteria as the ripened cream. In butter the total number of living bacteria decrease gradually.

The starter group is by far the most numerous and plays an important part in the ripening process. It is present in large numbers at every

step in the manufacturing manipulations (Fig. 3). During pasteurization about 70 percent of this group is killed. In the pasteurized cream they constituted over 50 percent of this total flora and about 95 percent in the ripened cream. During the twenty to thirty minutes of churning about 30 percent of the total flora were rendered unable to make a growth on the culture media; according to our data the starter group suffered the total of this loss. In butter they die more rapidly than the members of the other groups.

The gas producing bacteria and liquefiers. These groups which cause most of the undesirable flavors suffer great loss during the pasteurization. They increased during the ripening and their numbers were not reduced by churning. In butter their numbers remained almost con-

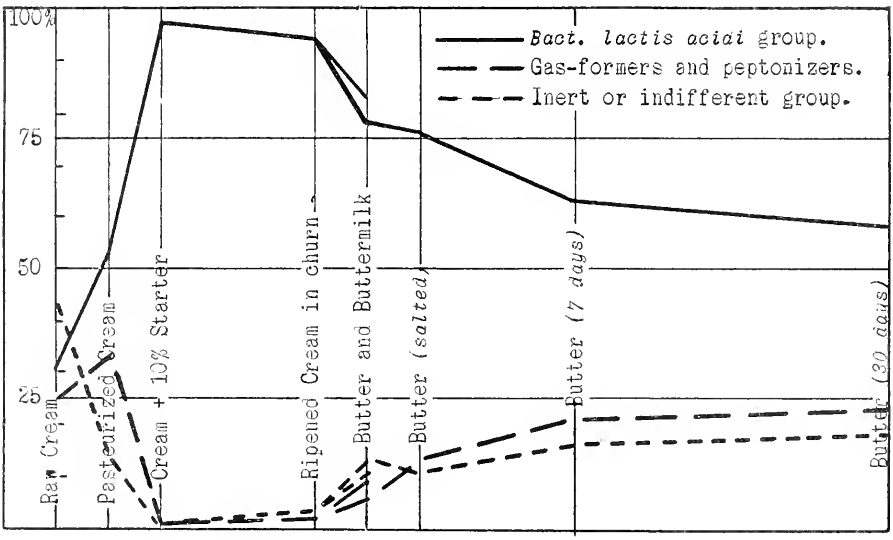

Fig. 3. *Graphic representation of the different types of microorganisms in per cent of the total flora found at different steps in the manufacture of butter (average of twelve churnings).*

stant. The gas producers including both the coli-aerogenes and the enteritidis sporogenes groups were present in varying numbers in the cream at all stages, but were not found in the butter. Other work in this laboratory shows that members of the coli-aerogenes group are found occasionally in butter after three weeks in storage. For their absence in butter we have no explanation to offer unless the agitation during the churning or the plasmolysis of the cell due to the added salt is destructive.

The inert or indifferent group of bacteria to which 10 to 25 percent of the total flora belong suffered a loss of about 97.5 per cent during pasteurization; increased during ripening, did not decrease during the churning and remained almost constant in the butter during thirty days.

Torulae and molds. Torulae, both liquefying and non-liquefying were found in every churning, pasteurization is highly destructive yet they

are found in the ripened cream and butter. *Oöspora lactis* is the predominating mold in butter.

Cultural study and frequency of occurrence. The study of the morphology and of the cultural and biochemical features of the various organisms isolated from the different churnings is not given in this paper for the sake of brevity. Table III gives a summary of the data upon the frequency that individual species were found in these twelve churnings. From each churning eight platings, representing different stages in the manufacture, were made. The figures in the table indicate the number of platings from which the type was obtained. While none but *Bact. lactis acidi* was omnipresent other types were frequent and were isolated several times in many of the churnings.

TABLE III.—THE NUMBER OF PLATINGS IN WHICH AN ORGANISM WAS FOUND IN THE DIFFERENT CHURNING EXPERIMENTS.

(Eight platings were made, at different periods, from each churning.)

Number of organism.	Churning No.											
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1	1	0	1	0	0	0	0	2	0	0	0	0
2	5	3	0	0	0	3	2	0	2	2	0	2
5	1	2	0	0	0	2	1	2	0	2	0	2
6	0	0	2	0	1	2	2	0	0	2	2	2
9	2	0	2	2	2	2	1	0	0	2	2	0
19	0	3	2	2	3	0	2	0	2	0	0	3
20	1	1	0	0	0	0	3	0	0	0	0	0
21	3	2	3	3	0	4	4	0	3	0	3	2
26	0	2	2	0	2	1	1	2	0	1	1	0
29	2	2	0	1	0	0	4	0	0	0	2	1
31	0	0	4	2	3	2	2	0	0	0	2	0
54	0	0	2	2	3	2	0	0	1	0	2	2
63	0	0	3	3	2	0	0	0	2	0	2	1
68	0	0	2	3	3	2	0	0	2	0	0	0
69	0	0	3	0	0	1	0	0	3	0	1	0
71	0	0	1	3	0	2	3	0	0	3	0	0
74	8	8	8	8	8	8	8	8	8	8	8	8
80	0	3	0	2	3	0	0	3	0	0	2	2
84	0	0	0	3	0	0	1	1	1	1	0	2
90	0	3	2	2	2	0	2	2	2	2	1	2
102	2	0	0	3	0	0	0	0	2	2	2	2
109	0	0	0	0	2	1	0	2	0	2	3	2
111	0	0	0	0	0	3	0	2	0	2	0	0
119	7	3	2	0	0	0	3	2	0	3	0	0
122	1	0	0	0	2	0	0	2	0	0	0	0
123	0	2	0	2	0	1	0	2	2	0	2	2
126	4	4	3	2	4	4	4	4	4	3	4	4

GENERAL DISCUSSION.

Our findings that a number of bacteria died during churning cannot be taken as universally true because the acidity of our cream is high and the total number of living organisms was near the maximum. It is the general knowledge and belief that when bacteria in cultures have reached the maximum number they die more or less rapidly due to the deleterious effect of waste products; this, and not the agitation in the churn, may be the prime cause of the death we observed. An underripe cream in which bacteria are capable of increasing to far greater numbers, if churned, might not show a reduction in numbers during the churning operations. It is obvious that the difficulties encountered in differentiating the various types in order to obtain a total count of any particular group are so great that the results, at best, are subject to great variations. Although it may be concluded that the numbers of the various types of microorganisms not including acid producers, organisms especially tolerant to acids, show little or no increase in sour cream after pasteurization. The same may be said of most microorganisms in butter.

SUMMARY.

1. The microorganisms in butter are for the greater part those that were in the cream.
2. Neither the buttermilk nor the freshly churned butter contain per unit volume as many living bacteria as the ripened cream. The average from our data shows that about 30 percent of the bacteria living in ripened cream fail to grow after the mechanical agitation in the churn.
3. The process of washing and salting removes about 50 percent of the microorganisms from the unsalted butter.
4. Positive tests for peroxidase and reductase were obtained in the cream and in the butter, but not in starter, in ripened cream or in buttermilk. The negative results are due to a temporary inactivation by high acidity.
5. *Bact. lactis acidi* is the predominating type throughout the manufacture of butter. Other organisms appearing frequently in our samples are *Micrococcus lactis varians*, *Micrococcus lactis aureus*, *Micrococcus lactis albidus*, *Streptococcus lactis fulvus*, *Bact. lactis album*, *B. coli*, torulae (liquefying and non-liquefying) and *Oöspora lactis*.

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FOREWORD.

TECHNICAL BULLETIN NO. 30.

Investigations dealing with the "Keeping Qualities of Butter" have been submitted for publication under the headings I, II and III, and IV and V. The results herein recorded are presented as a contribution to part V "Pasteurization and Its Influence" and represents a portion of a thesis submitted in 1915 by Kurt Peiser in partial fulfillment of the requirements for the degree of Master of Science at this institution. The research was conducted under the immediate direction and close supervision of Mr. Chas. W. Brown and prepared for publication by him. The junior author, now instructor in bacteriology at the Kansas Agricultural College, Manhattan, Kansas, is pursuing this phase of the investigation further.

WARD GILTNER.

KEEPING QUALITIES OF BUTTER.

V. PASTEURIZATION AND ITS INFLUENCE (CONTRIBUTION).

A STUDY OF THE FACTORS WHICH INFLUENCE THE RESISTANCE OF LACTIC ACID BACTERIA TO HEAT.*

CHAS. W. BROWN AND KURT PEISER.

INTRODUCTION.

The facts that commercial pasteurized milk develops an acidity and loppers in a manner characteristic of milk which has not been pasteurized, that plates made from pasteurized market milk and cream usually show a high percentage of acid-producing microorganisms, and that butter made from pasteurized cream without the addition of starter has lactic acid bacteria as the predominating flora, have directed our attention to the lactic acid group of bacteria. Inefficient pasteurization and subsequent contamination through utensils and containers of milk and cream which have been efficiently pasteurized were thought to be responsible for the presence in pasteurized milk and cream of large numbers of this group of bacteria.

PURPOSE.

The purpose of this work is to ascertain whether lactic acid bacteria in milk and cream survive pasteurization at a temperature commonly considered as efficient and whether such survival is due to an inherent property of the organism or due to some external protection exerted by the constituents of milk.

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*A report on this work, presented before the Society of American Bacteriologists 1914-15, is abstracted in Science n. ser. Vol. 42, p. 320.

LITERATURE REVIEW.

A non-spore-forming bacterium (*Bact. bulgaricum*) was studied by Leichmann (12) who states that to kill it in milk an exposure of 70° C. for two hours was required. The belief of Russell (16) is that to a large extent the lactic acid bacteria are destroyed by the pasteurization process. Marshall (13) observed that a large number of the samples of milk pasteurized at 68° C. for twenty minutes loppered with the production of acid, although no true lactics were found on plating. Among those isolated were four non-spore forming bacteria, three of which are able to survive 80° C. for twenty minutes in bouillon and the fourth withstood 70° C. for the same length of time. A number of streptococci and members of the colon group whose death point is high were isolated by Harrison (10). Gage and Stoughton (8) isolated a strain of *B. coli* whose thermal death point in bouillon was 80° C. They attempted to increase its resistance to heat by subculturing from the surviving few, but no increase in resistance was obtained. Dornie and Daire (7) state that *Bacillus surgeri* (an organism of the *Bact. bulgaricum* group) isolated from pasteurized whey resists a temperature of 85° C. for five minutes. Ayers and Johnson (1, p. 58) say that a temperature of 62.8° C. held for thirty minutes would be sufficiently high to afford protection against pathogenic bacteria and yet would leave in the milk the maximum proportion of lactic-acid bacteria and the group proportions would be very similar to those of all grades of market milk. In their conclusions they assume that the souring of pasteurized milk is due to the development of lactic acid bacteria that, on account of their high thermal death point in milk, survive pasteurization. White and Avery (22, p. 171) in their study of seventeen different strains of *Bact. bulgaricum* observed that a minimum exposure in whey of fifteen minutes at 60° C. was necessary to kill all the strains. Pease (14) states that members of the colon group are more difficult to kill by pasteurization than is *Bact. tuberculosis*. In commercial pasteurized milk of Wahington, Kinyoun (11) found high counts of colon bacilli and of streptococci. He attributed their presence to dirty milk inefficiently pasteurized. Data given by Ayers and Johnson (2) show that 1.2 percent to 4.5 percent of the lactic acid bacteria in raw milk survive pasteurization at 62.8° C. for thirty minutes. They give the thermal death point of a lactic acid organism isolated from pasteurized milk as 79.4° C. for thirty minutes in bouillon. Some acid-forming bacteria were found that have a thermal death point in bouillon ranging between 82° C. and 93.3° C. The determination of the thermal death point of one hundred and thirty-nine strains of streptococci isolated from various sources revealed to Ayers and Johnston (3) that 33.07 percent of the strains survived, in milk, a temperature of 145° F. for thirty minutes, that 2.58 percent survived at 160° F. and that all succumb at 165° F. They observed that the typical streptococci (those forming long chains) were less resistant to heat—seventeen from the eighteen strains were killed at 145° F.—than the atypical of which, at 145° F, 38.46 percent of the strains survived. Also that the strains from the udder are more re-

sistant than those from the mouth of the cow and from cow feces but less resistant than those from milk and cream. One strain upon which special work was done was not affected by a temperature of 150° F. for thirty minutes, at 160° F. from 53 to 99 percent of the individuals in the culture succumb and at 165° F. all were killed. These same authors (4) in a study of one hundred and seventy-four strains of colon bacilli state that in milk a temperature of 145° F. for thirty minutes caused the death of 93.02 percent of the strains and that all were killed at 150° F. The results from repeated determinations of the thermal death point of a given strain was observed to vary considerably. They conclude that, from their work, colon bacilli should not be expected in milk pasteurized at 150° F. for thirty minutes.

Working with *Bact. tuberculosis*, Theobald Smith (20) states that the tubercle bacilli suspended in distilled water, in normal salt solution, in bouillon or in milk are destroyed at 60° C. in fifteen to twenty minutes; while those on the surface of milk surrounded by the pellicle which forms during the exposure may be found alive after an exposure at 60° C. for sixty minutes. A micrococcus was isolated from pasteurized milk by Russell and Hastings (17) who tabulate data showing that its thermal death point in bouillon is 76° C. and in milk and whey is 77° C. Russell and Hastings (18) give data demonstrating that the thermal death point of a micrococcus in milk when determined in an open vessel is about 8° C. higher than when determined in sealed tubes. This difference they show to be due to the surface pellicle which formed on the milk during exposure. They conclude that the destruction of bacteria in milk by means of heat depends upon the conditions under which the exposure is made; the formation of a pellicle protects any organism within the pellicle. This protection is thought to be due largely to a lower temperature at the surface and to the nature of the membrane itself. In studying heat resisting strains of *B. Coli*, Zelenki (24) states that their thermal death point is higher in milk than in bouillon and suggests that the protein and fat are responsible for the protection. Barthel and Stenström (5) conclude that the cells of *Bact. tuberculosis* in whey are killed by heating to 80° C. providing the large lumps of coagulated casein have been removed by passing through a hair sieve—the small flakes which pass through the sieve are without effect. Rosengren (15) concludes from his data that bacteria are better protected against a high degree of temperature in raw milk than in milk sterilized by heat. Bartlett and Kinne (6) suspended the spores of *B. subtilis, Bact. anthracis* and *B. vitalis* in water, in glycerin, in olive oil, in cottonseed oil and in paraffin and subjected them to various degree of heat. They observed that in an autoclave under fifteen pounds pressure the spores of *B. vitalis* suspended in water were killed within fifteen minutes; but, when suspended in glycerin and in oil exposures for ninety minutes and two hours respectively were required. Hammer (9, p. 32) states that his unpublished data indicate that the acidity present in cream has an important influence on the destruction of the *Bact. lactis acidi* forms by heat. It is stated by Wolff (23, pp. 666-675, 737 and 744) that *Bact. güntheri* (*Bact. lactis acidi*) in sterilized milk, in bouillon and in water was killed within twenty minutes at 70° C. but that in raw milk members of this group survive for half an hour at 70° C. or for fifteen minutes at 80° C. He concludes that the protection is due to the forma-

tion around the cell of an acid coagulum of albumin. In the study of tubercule bacteria in naturally infected milk van der Sluis (21) observed that a temperature of 80° C. was necessary to insure destruction of this bacterium. He also observed that artificial cultures in media containing milk acquired an ability to withstand a slightly higher temperature than the *Bact. tuberculosis* normally present in milk. Schultz and Ritz (19) in studying the thermal resistance of young and old cells of a strain of *B. coli* observed that cultures three to six hours old were killed by an exposure for twenty-five minutes at 52° C. while cultures eight to twenty-four hours old survived and believe that the rapidly reproducing cells are less resistant than older individuals. Attention is called by Ayers and Johnson (1) to a lactic acid bacterium isolated from milk, the thermal death point of which is 74.4° C. in bouillon and 75.6° C. in milk when exposed in Sternberg bulbs for thirty minutes. When heated in milk for ten minutes the thermal death point is 77.8° C.

Nearly every investigator who has worked with pasteurized milk and cream believes that members of the *B. coli* and *Bact. lactis acidi* groups survive pasteurization and too, that members of these groups exist whose thermal death point is higher than the temperature commonly employed in commercial pasteurization. Many are of the opinion that the thermal death point determined in bouillon or in milk is the same, especially if the milk is sealed to prevent the formation of a surface pellicle or membrane; while others have discovered that the killing temperature of a number of microorganisms is higher in milk than in bouillon.

EXPERIMENTAL WORK.

METHODS.

Thermal Death Point. The thermal death point of a bacterium is that temperature which causes death of the vegetative cells during an exposure of ten minutes in bouillon unless otherwise stated. (As a matter of comparison the exposure was lengthened to twenty minutes, but when this is done specific mention of the fact will be made.)

Methods of Determination. One cubic centimeter of a twenty-four hour bouillon culture was introduced into test tubes containing about 10 c.c. each of the sterile medium in which the thermal death point is to be determined. Duplicate tubes were placed in a water bath at the desired temperature, which was not allowed to vary over 0.5° C. for ten minutes, then they were removed immediately and cooled below 25° C. Special precaution was taken not to permit the bouillon culture to come in contact with the walls of the tube above the medium and to have the surface of the medium in the tube below the level of the water in the bath. The tubes were incubated at a temperature optimum for the bacterium under consideration (25 to 30° C. for *Bact. lactis acidi* and 37° C. for *B. coli*). The bacteria in the duplicate tubes, when neither shows growth within five days, are regarded as having been killed and are recorded negative for that specific temperature.

Another method used for comparison is the same as the above described with the exception that a layer of sterile liquid paraffin about one-half inch in depth was placed upon the medium just before the exposure in the water bath. The paraffin, which serves to exclude the air and to prevent the possible formation of a surface pellicle, remained in the tubes during the incubation period.

Sternberg Bulbs also were used for comparison. They were filled with the suspension, exposed in a water bath at the desired temperature for the required length of time, cooled and emptied into tubes of litmus milk.

VARIATION IN THE TEMPERATURE OF CREAM DURING PASTEURIZATION.

A "Perfection" pasteurizer (200 gallon capacity) installed in the College Dairy Department was used for this work. It contains a block tin spiral tube through which water of any desired temperature can be pumped. The spiral is made to rotate and to serve as a stirring device. Observations were made in cream which was pasteurized by the holding process at 145° F. for 20 minutes and which was used for churning in the College dairy. The temperature was read at intervals at a depth of about four inches near the corners and in the center of the pasteurizer and also in the surface of the cream. The data obtained (Table I) show a very slight variation in the temperature of the cream at different points during the pasteurization and indicate that the process employed would be considered efficient.

TABLE 1.—VARIATION IN THE TEMPERATURE OF CREAM DURING PASTEURIZATION BY THE HOLDING PROCESS.

Time.	Lot A.—Location in the pasteurizer.				
	N. E. corner.	N. W. corner.	S. W. corner.	S. E. corner.	Center.
Beginning of holding period	145°F*	145°F	144°F	144°F	145°F
4	144	145	144	146	145
8	145	145	145	145	144
12	145	145	144	144	144
16	145	145	145	145	145
20	145	145	146	145	146

Time.	Lot B.—Location in the pasteurizer.					
	N. E. corner.	N. W. corner.	S. W. corner.	S. E. corner.	Center.	Surface.
Beginning of holding period	62.1°C†	62.0°C	61.7°C	62.2°C	62.3°C	62.0°C
4	63.2	63.1	63.1	63.2	63.2	62.9
8	63.3	63.2	63.2	63.4	63.3	63.1
12	62.9	63.0	62.8	63.1	63.0	62.5
16	62.4	62.6	62.5	62.5	62.6	62.2
20	61.8	61.7	61.7	61.8	61.8	61.5

*Taken with a dairy thermometer.
†Taken with a certified thermometer graduated in 0.1°C.

COMPARISON OF METHODS FOR DETERMINING THE THERMAL DEATH POINT.

The thermal death points of four bacteria were determined in separated milk and in cream by each of the three methods described above. The results (Table II), show the harmony of these methods.

TABLE 2.—COMPARISON OF THE THERMAL DEATH POINT AS DETERMINED BY DIFFERENT METHODS.

Name of bacteria.	Open tube.		Paraffin covered.		Sternberg bulbs.	
	Skim milk.	Cream.	Skim milk.	Cream.	Skim milk.	Cream.
Bact., No. 10211	60°C	69°C	60°C	69°C	60°C	63°C
Bact., No. 10212	63	71	63	71	63	71
Bact., No. 10213	63	71	63	69	63	69
B. coli., No. V	65	73	63	73	65	73

THERMAL DEATH POINT OF LACTIC ACID BACTERIA FOUND IN PASTEURIZED MILK AND CREAM.

A number of different species and strains of microorganisms were found in samples of pasteurized milk and cream obtained from various sources, but only those of the acid producing types are considered to any extent in this work. The thermal death point of twelve strains of *Bact. lactis acidi* and of four strains of *B. coli* were determined and are tabulated in Table III. A variation of 22° C. (from 56° to 78° C) in the thermal death point of these strains was found. Seven of the twelve *Bact. lactis acidi* and two of the four *B. coli* have a thermal death point high enough to survive pasteurization (145° F. for 20 minutes). When bacteria with this inherent property are present in milk or cream we can not hope to exterminate them by the usual temperature of pasteurization. But when bacteria whose thermal death point is below the tem-

TABLE 3.—THERMAL DEATH POINT DETERMINATIONS.

(Average of 5 determinations in bouillon, open tube method).

Name of bacteria.	Length of exposure.	
	10 min.	20 min.
Bact. lactis acidi, No. 5	56°C	52°C
Bact. lactis acidi, No. 1	58°C	56°C
Bact. lactis acidi, No. 4	62°C	58°C
Bact. lactis acidi, No. 12	64°C	62°C
Bact. lactis acidi, No. 9	66°C	62°C
Bact. lactis acidi, No. 8	68°C	66°C
Bact. lactis acidi, No. 2	72°C	68°C
Bact. lactis acidi, No. 10	72°C	68°C
Bact. lactis acidi, No. 11	74°C	72°C
Bact. lactis acidi, No. 6	76°C	72°C
Bact. lactis acidi, No. 3	76°C	74°C
Bact. lactis acidi, No. 7	78°C	74°C
Bacillus coli, No. 4	56°C	52°C
Bacillus coli, No. 2	60°C	58°C
Bacillus coli, No. 3	70°C	68°C
Bacillus coli, No. 1	74°C	70°C

perature of pasteurization are alive in the pasteurized product, some compound or property in the milk or cream has given them protection.

PROTECTIVE INFLUENCE OF MILK.

The thermal death point of a culture of *Bact. lactis acidi* and of a culture of *B. coli* were compared in bouillon and in sterile separated milk. The average of twelve determinations establishes the thermal death point in milk 3.5° to 4° C. higher than in bouillon (*Bact. lactis acidi* No. 12, in bouillon 64° C. in milk 68° C. and *B. coli* No. 3, in bouillon 69.5° C. in milk 72° C.) With the idea of extending this comparison a portion of a lot of fresh milk was filled into test tubes, the remainder was separated and tubes filled with the cream (25 percent fat) and with the separated milk. Some separated milk was treated with rennet and the whey filtered and tubed. This gives us four divisions of the same milk, i. e., whole milk, cream, separated milk and whey all of which were sterilized intermittently in flowing steam. In these subdivisions the thermal death point of several milk bacteria were determined. The results which are tabulated in Table IV make it clear that the thermal death point of bacteria determined in milk or in cream is higher than that for the same organism determined in bouillon. Whey itself possessed some property which raised the thermal death point from 2° to 4° C.; separated milk from 4° to 6° C, whole milk about 8° C. and cream from 12° to 14° C. The non-acid producing bacilli Nos. 16 and 14a received the same protection from milk and cream as did the acid producers. In the light of this observation it is not strange that bacteria in milk and cream whose thermal death point in bouillon is a few degrees below the pasteurization temperature are not killed by pasteurization.

TABLE IV.—THERMAL DEATH POINT AS DETERMINED IN VARIOUS MEDIA.

Medium.	Temperature of exposure in degrees centigrade.														
	51.	53.	55.	57.	59.	61.	63.	65.	67.	69.	71.	73.	75.	77.	79.
Bact. lactis acidi, No. 10211:															
Cream	+	+	+	+	+	+	+	+	+	−	−	−	−	−	−
Whole milk	+	+	+	+	+	+	−	−	−	−	−	−	−	−	−
Skim milk	+	+	+	+	−	−	−	−	−	−	−	−	−	−	−
Milk serum	+	+	+	−	−	−	−	−	−	−	−	−	−	−	−
Bouillon	+	+	−	−	−	−	−	−	−	−	−	−	−	−	−
Bact. lactis acidi, No. 10212:															
Cream	+	+	+	+	+	+	+	+	+	+	−	−	−	−	−
Whole milk	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−
Skim milk	+	+	+	+	+	+	−	−	−	−	−	−	−	−	−
Milk serum	+	+	+	+	+	−	−	−	−	−	−	−	−	−	−
Bouillon	+	+	+	−	−	−	−	−	−	−	−	−	−	−	−
Bact. lactis acidi, No. 10213:															
Cream	+	+	+	+	+	+	+	+	+	+	−	−	−	−	−
Whole milk	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−
Skim milk	+	+	+	+	+	+	−	−	−	−	−	−	−	−	−
Milk serum	+	+	+	+	+	−	−	−	−	−	−	−	−	−	−
Bouillon	+	+	+	−	−	−	−	−	−	−	−	−	−	−	−
B. coli, No. V:															
Cream	+	+	+	+	+	+	+	+	+	+	+	−	−	−	−
Whole milk	+	+	+	+	+	+	+	+	+	−	−	−	−	−	−
Skim milk	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−
Milk serum	+	+	+	+	+	+	−	−	−	−	−	−	−	−	−
Bouillon	+	+	+	+	+	−	−	−	−	−	−	−	−	−	−
Non-acid Baccillus, No. 16. (Isolated from pasteurized cream):															
Cream	+	+	+	+	+	+	+	+	+	+	+	+	+	−	−
Whole milk	+	+	+	+	+	+	+	+	+	+	−	−	−	−	−
Skim milk	+	+	+	+	+	+	+	+	+	−	−	−	−	−	−
Milk serum	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−
Bouillon	+	+	+	+	+	+	−	−	−	−	−	−	−	−	−
Non-acid Bacillus No. 14a. (Isolated from pasteurized cream):															
Cream	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−
Whole milk	+	+	+	+	+	−	−	−	−	−	−	−	−	−	−
Skim milk	+	+	+	−	−	−	−	−	−	−	−	−	−	−	−
Milk serum	+	+	−	−	−	−	−	−	−	−	−	−	−	−	−
Bouillon	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Bact. bulgaricum, No. 10251:	67.	69.	71.	73.	75.	77.	79	81.	83.	85.	87.	89.	91.	93.	95.
Cream	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−
Whole milk	+	+	+	+	+	+	+	+	+	+	+	+	−	−	−
Skim milk	+	+	+	+	+	+	+	+	+	+	+	−	−	−	−
Milk serum	+	+	+	+	+	+	+	+	+	−	−	−	−	−	−
Bouillon	+	+	+	+	+	+	+	+	−	−	−	−	−	−	−

ACIDIFIED MILK.

When the thermal death point of three strains of *Bact. lactis acidi* was determined in sterile separated milk to which was added normal lactic acid (commercial) no effect of the acid was noticed. (Table V.)

TABLE V.—THERMAL DEATH POINT DETERMINED IN ACIDIFIED MILK.

(Average of 20 determinations).

Name of bacterium.	Check. reaction 15°.*	Lactic acid added.	
		Reaction 25°.*	Reaction 40°.*
Bact. lactis acidi, No. 10211	57°C	57°C	57°C
Bact. lactis acidi, No. 10212	61°C	61°C	61°C
Bact. lactis acidi, No. 10213	61°C	61°C	61°C

*A degree (°) means per cent N/10.

GENERAL DISCUSSION.

As further work on several points of this subject is well under way a detailed discussion of the many factors will not be undertaken at this time: yet it will not be out of place to mention some of the factors which may or may not influence the resistance to heat (thermal death point) of bacteria in milk. It is understood that the composition of milk from different cows is not the same and that the milk from the same cow at different milkings or even at the same milking is not uniform. If media of different composition have anything to do with raising or lowering the thermal death point of bacteria therein, then all factors which modify milk or cause variation in its composition may influence directly or indirectly, favorably or unfavorably the ability of bacteria to survive high temperatures. Physical and chemical conditions of the medium in which bacteria are subjected to heat are not without influence upon the thermal death point. Media with low or high specific heat would subject the bacteria to sudden or retarded changes in temperature when they are placed in the hot water bath and when they are cooled by placing in cold water. A sudden chilling of bacteria, as when the thin wall capillary tube is plunged into cold water after the ten minutes exposure, may be decidedly detrimental. The use of sealed containers as Sternberg bulbs or capillary tubes might have an influence because the exposure to heat during the determination would create an internal pressure which, in itself, is a potent factor in hastening death. The evaporation in unsealed tubes would lower the surface temperature at the time of exposure, thus permitting the bacteria in the surface to survive when all below the surface have succumbed. A possible indirect effect of evaporation may be the production of a drier heat in the surface of the medium due to the concentration of its soluble and suspended matter. The formation of a pellicle on raw milk due to the coagulation of albumen, to surface drying and to oxidation when milk is heated in contact with air is,

without question, a protection to bacteria within the pellicle. In cream the fat itself may have protective properties or the protection may be indirect and due to a large amount of dry matter with a comparatively low percentage of water. Raw milk may offer greater or less protection than milk sterilized by heat. Whether the protective property of casein is due to the formation around the bacterial cell of an acid or rennet curd, brought about during the exposure through the agency of the enzymes liberated by the cell, is a question for further study. The possibility that the reducing action of lactose or the action of reductase may have an influence can not be ignored. The presence of products and of by-products of bacterial growth undoubtedly has something to do with a bacterium's maximum endurance of heat. It must be admitted that the death of bacteria, when subjected to heat, may be postponed or hastened by the presence of enzymes (reducing, oxidizing and hydrolytic) of animal and of bacterial origin. It is not improbable that the age of an individual cell i. e. the two cells the moment after division and the cells hardened with age; that the physical condition of the cell i. e. a cell in the act of division, a cell rapidly synthesizing vital protoplasm, a cell resting but maintaining life, an involuted form or a stage in the life cycle; and that the formation within the cell or the exudation from the cell wall—permitted or even favored by the nature of the medium upon which the cell is nourished—of protective substance i. e. the storing of fats, carbohydrates, sulfur, etc., within the cell and the excretion of waste products, gums, muculent substances, etc., are determining factors in raising or lowering the resistance of cells to the devitalizing action of high temperatures. In the pasteurization of dairy products and in the control of infectious diseases the resistance of microorganisms to heat is a question of great magnitude and a problem for research.

SUMMARY.

1. The temperature of cream during pasteurization by the holding process in a "Perfection" pasteurizer (with coil rotating) was found to be almost constant throughout the whole mass: The temperature in all parts of the cream at a stated time showed a variation of less than one degree.

2. The thermal death point, determined in bouillon, of some of the non-spore bearing bacteria isolated from pasteurized milk and cream is higher than the pasteurization temperature (62.5° C. or 145° F. for 20 min.), while many have a thermal death point below the temperature of pasteurization.

3. The casein and fat in milk offer some protection to bacteria that are subjected to high temperature during the death point determination.

4. No pellicle was observed to form in any of the tubes of milk during the exposure. The plain cotton plugged tubes, the tubes with paraffin oil on the surface of the medium and the Sternberg bulbs gave concordant results in the thermal death point determinations.

5. The addition of small amounts of lactic acid to a milk suspension of the bacteria did not change their thermal death point.

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INTRODUCTION.

Technical Bulletin No. 31.

GEORGE J. BOUYOUCOS AND M. M. MCCOOL.

In a former publication (1) the freezing point method was presented as a new means of measuring the concentration of the soil solution directly in the soil mass, at various moisture contents and under different fertilizer treatments. The general results yielded by the method appeared on the whole quite revolutionary and in some respects almost incredible. With the desire to establish, as far as it was possible, the absolute truthfulness of the method and consequently the reliability of the results, the general investigation was repeated a second time and greatly extended. In the second investigation an attempt was made to be extremely critical both with the method and the results obtained. The general method was somewhat modified and in certain essential details greatly improved. The scope of the investigation was considerably enlarged by employing a greater number of soils, which were obtained from various parts of the country, and by applying to these soils a greater number of treatments.

It is a personal source of gratification to us now to state that the results obtained in the first investigation, the general conclusions drawn therefrom, and the various explanations offered, are fully and entirely confirmed and substantiated by these later improved, greatly extended and more critical researches. We are now confidently convinced that the freezing point method gives truthful and reliable results on the freezing-point lowering of soils at various moisture contents and under different fertilizer treatments.

Since the appearance of the first paper already referred to, the freezing point method has been applied in studying other problems besides those already mentioned. Some of the problems investigated by this method may be mentioned as follows: (a) Measuring the concentration of the plant cell sap directly in the plant tissue (2), (b) Measuring biological actions directly in the soil (3), (c) Determining the nature of acidity and lime requirement of soils (4). The experience gained from these varied studies and the opportunity they offered to test out the method have amply confirmed and greatly strengthened the above conviction.

It is the object of the present bulletin, therefore, to present the additional data obtained by the freezing point method on the concentration of the soil solution at various moisture contents and under various other treatments, to compare these results with those of the first investigation,

(1) Bouyoucos, G. and McCool, M. M.—The Freezing Point Method as a New Means of Determining the Concentration of the Soil Solution Directly in the Soil. Tech. Bul. 24, Mich. Exp. Stat., 1916.
(2) Bouyoucos, G. and McCool, M. M.—Determination of Cell Sap Concentration by the Freezing Point Method. Jour. Am. Soc. Agr., Vol. 8, No. 1, 1916.
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(4) Bouyoucos, G.—The Freezing Point Method as a New Means of Determining the Nature of Acidity and Lime Requirements of Soils. Tech. Bul. 27, Mich. Expt. Sta., 1916.

to examine more critically the possible explanations for these results, to present the new modifications made in the apparatus and procedure, etc.

Since the original experimental data, general conclusions and hypotheses are confirmed and substantiated by the further researches presented in the present bulletin, a large portion of the general discussion of the former bulletin is here naturally repeated. Other material which was deemed essential for an intelligent and convenient treatment of the present paper, is also repeated.

PRINCIPLE OF THE METHOD.

The determination of the freezing-point lowering of soils and consequently the concentration of their soil solution, is based upon the well known principle that the freezing point of water is lowered by the presence of soluble material and that the degree of the lowering is proportional to the amount of soluble material present in the case of non-electrolytes; and somewhat greater than proportional in the case of electrolytes before infinite dilution is reached. From the freezing point depression the concentration of a solution can be estimated. Since the soil solution contains soluble material dissolved from the soil mass which it bathes, its freezing point will be lowered according to its concentration.

DESCRIPTION OF THE METHOD AND THE PROCEDURE.

For determining the freezing point lowering of soils the Beckmann apparatus was again employed but with many radical modifications. The complete set of apparatus used is shown in Fig. 1. It is composed of a Beckmann thermometer A, a glass tube B which contains the soil, a larger glass tube C which acts as an air jacket, and the cooling bath D which contains crushed ice and NaCl. The glass tube B is 1 inch in diameter and 9 inches long, while glass tube C is 1.5 inches in diameter and 6 inches long. The cooling bath D which is different from that used in the first investigation, consists of two earthen-ware jars one inside the other. The outer jar is of 4-gallon capacity and the inner of 2-gallon capacity. The space between the two jars is filled with asbestos. In order to keep this asbestos dry the upper part is made water proof with paraffin and thus prevents any water falling into the space between the two jars. The top of the bath is covered with a board which contains several holes for placing the tubes into the ice mixture. This form of cooling bath proved more satisfactory than the Beckmann bath employed in the first investigation.

The temperature maintained in this bath varied with the depression of the soil. For soils with high moisture content or with a very small lowering of the freezing point the temperature was maintained at about —2°C. For soils with very low water content or with very high freezing-point lowering, the temperature was usually kept at about —3°C.

For calibrating the thermometer or determining the freezing point of

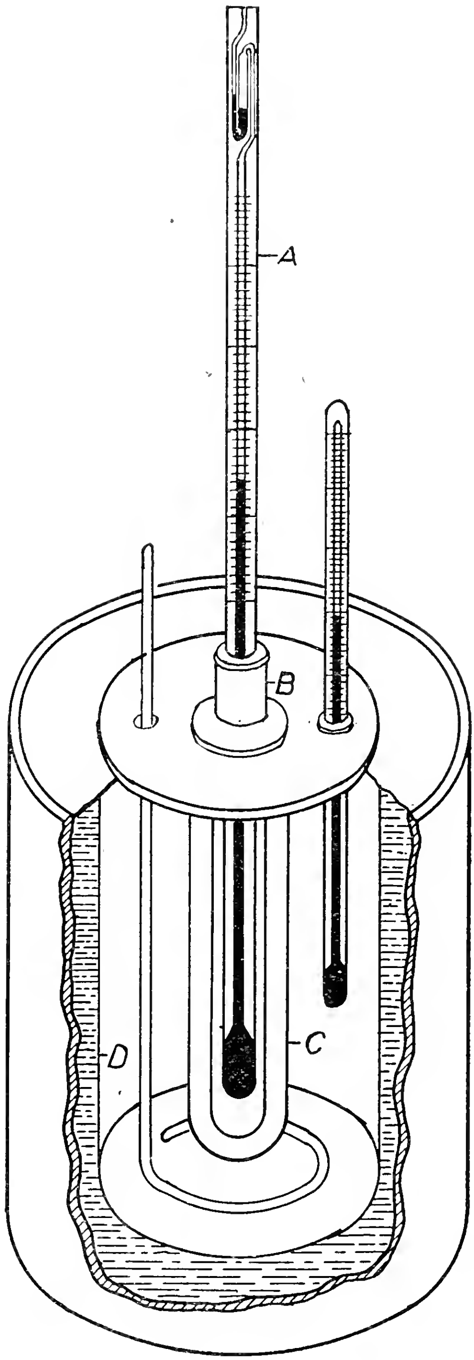

Fig. 1. Apparatus for determining the depression of soils.

water a second cooling bath was employed. This bath was exactly the same in form as the above, except that its temperature was maintained at about —5 or —6°C. It was found necessary to have this second cooling bath with such high temperature below zero degree because water would not freeze very readily at the temperature of —2 or —3°C of the first bath, but it would at the temperature of —5 or —6°C. Also, since the thermometer was calibrated with distilled water very often in the course of a series of freezing-point lowering determinations it was found very convenient and time-saving to have a separate cooling bath with the proper temperature.

The original procedure of determining the freezing-point lowering of soils was considerably changed in the second investigation. In the present investigation the following procedure was employed: First, the thermometer was set so that the mercury thread would come to rest toward the upper part of the scale when the bulb was held in a mixture of pure ice and distilled water. The freezing point of distilled water was then determined and this point was used as a standard for ascertaining the freezing point lowering of soils. Then the freezing point of soils was ascertained by placing in the tube B a column of soil of about an inch in height and inserting the bulb of the thermometer into this column of soil until it was completely covered. The tube containing the soil and the thermometer was placed directly in the cooling mixture through one of the holes in the cover and allowed to supercool to about 1°C. Then by holding the tube near its mouth with one hand and with the other moving the thermometer, solidification was started in the soil. Immediately upon the commencement of solidification, as indicated by the rise in temperature, the tube was at once taken out of the cooling mixture and put in the air jacket. The temperature was allowed to rise until it came to rest at a certain point on the scale and remained at that point for some time. This maximum temperature obtained was considered as the proper freezing point of the soil and recorded. The thermometer was always tapped before taking the final reading.

By placing the soil to cool directly in the cooling mixture instead of in the air jacket as was done previously, the desired supercooling was attained in a very short time, usually in about 10 minutes. Also by maintaining the temperature of the ice mixture at —2 or —3°C the loss of heat from the soil was considerably less than that at —5°C as used in the first investigation, and consequently the error, if any, in the results was smaller in the low temperature below zero than in the high.

If the temperature of the bath was greater than —2 or —3°C, solidification would start in the soil before supercooling had taken place, and of course the proper freezing point of the soil could not be accurately ascertained. But if the temperature of the cooling mixture was not greater than the above limits no difficulty would be experienced in supercooling the soil.

It was not found advisable to reduce the decree of supercooling. Although 1°C supercooling is considerable, it is believed that no serious errors arise therefrom.

For preparing samples of soil to determine their freezing-point lowering the following method was employed: For low moisture content about 20 grams of air dry soil was taken in the case of sandy loams, silts, and clays, about 30 grams of sands, and about 10 grams of mucks and peats, and mixed well with the desired amount of water. The mixing consisted

of working the soil between the fingers and passing it through a sieve several times. When the sample appeared quite uniformly moistened it was placed in a freezing tube, the latter closed with a rubber stopper, and the soil allowed to remain in the tube at room temperature for about 24 hours. At the end of this period the lowering of the freezing point of each sample of soil was measured in the tube in which it was originally placed.

For very high moisture content somewhat larger amounts of soil were taken. These soil samples were put in a large evaporating dish, the desired quantity of water added to them, and then mixed and worked with the hands. When sufficiently mixed they were placed in the tubes, and their freezing-point depression was determined in the same manner as above. Those soils which had a tendency to be sticky at the high moisture content were placed in the tube most conveniently by making the wet sample into a round elongated stick and dropping it into the tube.

Whenever it was desired to ascertain the freezing-point lowering of a soil just as it came from the field, it received no other treatments except thorough mixing.

The object of thoroughly mixing the samples, especially at the low moisture content, was to moisten all the particles of the soil. If some particles of a soil sample were not moistened, the freezing point lowering would not be accurately determined. But if they were all sufficiently moistened so that their film would freeze upon supercooling the freezing-point depression attained would be an average of the depression of all the various particles.

The freezing-point depression of all soils could be measured from any maximum moisture content down to a very low water content. The minimum percentage of moisture is probably slightly below the wilting coefficient of soils. Below this minimum water content solidification could not be induced, at least very readily, and the results could not be depended upon. One of the principal reasons for this is that there is not sufficient free water present to separate upon freezing to bring the temperature of the system to its proper freezing point.

At the high moisture content the freezing point lowering of a soil could be duplicated almost exactly at successive freezings, but at the low moisture content the duplicate determination would vary but the variation was always consistent. The explanation for this phenomenon will be offered subsequently.

The difficulty previously experienced in the sudden change of the calibration of the thermometer was met also in the present research. This change did not always happen but it did occur occasionally. The amount of change was usually insignificant and in the case of soils short of saturation, could be ignored. To guard, however, against any error arising from this source, the thermometer was calibrated very often during a series of freezing-point lowering determinations.

It should be emphasized that the foregoing description of the apparatus and procedure contains mainly the important improvements and modifications made during the course of the second investigation. For fuller and more complete details of the method and procedure the reader is referred to the first paper already mentioned.

Having given a brief description of the method, a consideration of the experimental results is next in order.

EXPERIMENTAL DATA.(a)

THE FREEZING-POINT LOWERING OF SOILS AT LOW AND HIGH MOISTURE CONTENT.

In accordance with the foregoing improved method the freezing-point lowering of a great number of soils was determined. These soils varied greatly both in type and origin. They were obtained from ten different states and were supposed to represent the typical types of these respective states. In these states are included California, Washington, Wisconsin, Minnesota, Michigan, Kentucky, Texas, Florida, Rhode Island, and Pennsylvania (5). From many of these states nearly all the main and important types existing in them were employed in this investigation. In all 58 soils were used. The object of procuring soils from the different states was to ascertain the magnitude of their freezing-point depression and hence the concentration of their soil solution. The cultural history of many of these soils is known for several years back and therefore a comparison between the concentration of their solution and their cultural treatment can be made.

All these soils were used in the air dry state. Their freezing point depression was determined at two different moisture contents, low and high. The object for employing these two opposite and extreme water contents was to ascertain the variation in the depression. The low moisture content represents very nearly the minimum water content at which solidification starts very readily and the results can be relied upon. These low water contents were selected from a large number tried in each soil. It must be emphasized, however, that they do not represent in every case the exact point where solidification started readily, but only approximately.

The high moisture content may be taken to represent the point of saturation. At this degree of water content the absorptive power of the soil for water is quite satisfied. The addition of more water above this point remains as gravitational water.

The magnitude of the freezing-point lowering of the various soils obtained at the two opposite moisture contents is shown in Table 3. The percentage of water is expressed on the oven-dry basis.

In the same table there are given the magnitude of concentration and osmotic pressure that the depression of each soil at both moisture contents represents. The concentration is expressed in parts per million of solid material in one million parts of solution and was calculated directly from soil water extracts and not from any particular pure chemical compound or a combination therefrom. The procedure of accomplishing this consisted of mixing 100 grams of soil with 500 c. c. of pure distilled water, allowing the mixture to stand for about two days with occasional

(a) The authors wish to express their gratitude and indebtedness to Mr. M. Wolkoff, a former graduate student, for his aid in procuring some of the experimental data.

(5) In procuring these soils from other states the writers are thankful and indebted to Prof. A. Whitson of Wisconsin Agricultural College, Prof. Chas. Shaw of California Agricultural College, Prof. G. Roberts of Kentucky Agricultural College, Prof. G. S. Fraps of Texas Agricultural College, Prof. W. C. Etheridge of Florida Agricultural College, Prof. S. Severance of Washington Agricultural College, Prof. F. Alway of Minnesota Agricultural College, Prof. White of Pennsylvania Agricultural College, and Prof. Pember of Rhode Island Experiment Station.

stirring and then filtering the supernatant liquid through Chamberland-Pasteur filters under pressure. A portion of this solution was used to determine its lowering of the freezing point and another portion was employed to find its total solid matter by evaporating a definite volume of it to dryness and weighing the residue. From the freezing-point depression of the extract and its corresponding amount of solid material present the concentration in p. p. m. of solution that is represented by the values of the freezing-point lowering of each soil was calculated. Thus, for instance, supposing that the lowering of the freezing point of the solution was .009°C and the weight of the residue in 100 c. c. of the solution was .020 grams. By calculation, .020 grams of solid material in 100 c. c. of solution is equivalent to 200 p. p. m. of solution. Therefore, 200 parts of solid material in one million parts of solution caused a depression of .009°C. By means of this simple calculation therefor the concentration in p. p. m. that the various values of the freezing point lowering represent, was easily calculated.

There were a great number of soils representing a large number of types from which soil water extracts were made in order to ascertain the relation between the magnitude of the depression and the total solid matter present. In Table I there are shown the results obtained on the lowering of the freezing point and the weight in grams of solid matter in 100 c. c. of solution.

Table 1. Comparison Between Lowering of the Freezing Point and Weight of Residue of Soil Water Extracts.

Filtrates	Freezing point depression. °C	Weight of residue per 100 c. c. of solution. Gms.
Kentucky Carrington loam	.012	.0127
Kentucky LaCrosse sandy loam	.012	.0132
Pennsylvania silt loam	.002	.0075
Pennsylvania silt loam	.002	.0056
Texas Crawford clay	.009	.0236
Texas brownish-black loam	.002	.0097
Texas Norfolk sandy loam	.002	.0062
California Chino silty clay loam	.007	.0214
California Holland loam	.002	.0055
California Oakley fine sandy loam	.002	.0043
Wisconsin Superior clay	.002	.0076
Wisconsin Miami silt loam	.008	.0146
Wisconsin Plainfield fine sand	.002	.0044
Minnesota clay	.004	.0185
Minnesota sandy loam	.011	.0255
Minnesota sand	.002	.0057
Florida Prairie sand	.002	.0064
Florida Prairie sand	.002	.0062
Florida Prairie sand	.002	.0051
Michigan heavy silt loam	.006	.0100
Michigan heavy silt loam	.007	.0263
Michigan light clay loam	.005	.0161
Michigan heavy silt loam	.004	.0101
Michigan fine sandy loam	.009	.0150
Michigan sand	.004	.0094
Michigan fine sand	.003	.0051
Michigan light sandy loam	.007	.0273
Michigan muck	.011	.0527
Michigan peat	.011	.0606

It will be seen from the above table that with few exceptions there is quite a close relation between the degree of lowering of the freezing-point and the weight of the solid matter in solution. On the other hand it will also be observed that both the depression and the weight of the residue vary considerably between the solutions of the various soils. Thus, for instance, the depression varies from .002°C in some of the sands to .012°C in some of the loams, while the weight of the residue ranges from .0043 grams in some of the sands to .0263 grams in some of the loams.

At this point it should be mentioned that it is questionable whether all the residue represents material which was in solution and affected the depression of the freezing point. It appears very possible that some of this residue consisted of solid particles of microscopic size. Although the solutions were passed through the Chamberland-Pasteur filter and appeared very clear, they still could contain solid particles of microscopic size which had no influence upon the freezing-point depression. In the light of our present knowledge of colloids the soil solutions may be considered in part at least as colloidal solutions and may contain solid particles of microscopic size which are able to go through the various common filters.

In spite of the error caused by the colloidal particles in the residue, it is believed that a more true estimation of the concentration represented by the freezing-point depression values can be obtained from the soil water extracts than from pure chemical solutions.

For performing the actual computation of the concentration of the soil solution of the various soils as represented by the freezing-point lowering, an average was taken of the depression and of the residue of all the soils shown in Table 1 except the muck and peat. From these averages the amount of depression that 100 p. p. m. produced was calculated. The average depression amounts to .0041°C. For the calculation of the concentration of the solution of peat and muck, the depression and weight of residue obtained from the extracts of these soils, were used. It would undoubtedly have been better to have used also the depression and weight of residue of the extract of each mineral soil to compute the concentration of its solution, rather than to employ the above average. By using the average the concentration of the solution of some soils is much higher than it should be, while that of others somewhat lower.

The osmotic pressure was calculated from a table of osmotic pressures as worked out by Harris and Gortner (6) from a formula $\pi = 12.06 \triangle - 0.021 \triangle^2$, where π is the osmotic pressure in atmospheres, and $\triangle$ the lowering of the freezing point in centigrade degrees. Fon convenience and immediate usefulness this table is reproduced herewith.

(6) Am. Jour. Bot. 1, 75-78, 1914.

Table 2. Osmotic Pressure in Atmospheres for Depression of the Freezing Point to 2.999 °C.

	Hundredths of Degrees, Centigrade.									
	0	1	2	3	4	5	6	7	8	9
0.0	0.000	0.121	0.241	0.362	0.482	0.603	0.724	0.844	0.965	1.085
0.1	1.206	1.327	1.447	1.458	1.688	1.809	1.930	2.050	2.171	2.291
0.2	2.412	2.532	2.652	2.772	2.893	3.014	3.134	3.255	3.375	3.496
0.3	3.616	3.737	3.857	3.978	4.098	4.219	4.339	4.459	4.580	4.700
0.4	4.821	4.941	5.062	5.182	5.302	5.423	5.543	5.664	5.784	5.904
0.5	6.025	6.145	6.266	6.386	6.506	6.628	6.747	6.867	6.988	7.108
0.6	7.229	7.349	7.469	7.590	7.710	7.830	7.951	8.071	8.191	8.312
0.7	8.432	8.552	8.672	8.793	8.913	9.033	9.154	9.274	9.394	9.514
0.8	9.635	9.755	9.875	9.995	10.12	10.24	10.36	10.48	10.60	10.72
0.9	10.84	10.96	11.08	11.20	11.32	11.44	11.56	11.68	11.80	11.92
1.0	12.04	12.16	12.28	12.40	12.52	12.64	12.76	12.88	13.00	13.12
1.1	13.24	13.36	13.48	13.60	13.72	13.84	13.96	14.08	14.20	14.32
1.2	14.44	14.56	14.68	14.80	14.92	15.04	15.16	15.28	15.40	15.52
1.3	15.64	15.76	15.88	16.00	16.12	16.24	16.36	16.48	16.60	16.72
1.4	16.84	16.96	17.08	17.20	17.32	17.44	17.56	17.68	17.80	17.92
1.5	18.04	18.16	18.28	18.40	18.52	18.64	18.76	18.88	19.00	19.12
1.6	19.24	19.36	19.48	19.60	19.72	19.84	19.96	20.08	20.20	20.32
1.7	20.44	20.56	20.68	20.80	20.92	21.04	21.16	21.28	21.40	21.52
1.8	21.64	21.76	21.88	22.00	22.12	22.24	22.36	22.48	22.60	22.72
1.9	22.84	22.96	23.08	23.20	23.82	23.44	23.56	23.68	23.80	23.92
2.0	24.04	24.16	24.28	24.40	24.52	24.63	24.75	24.87	24.99	25.11
2.1	25.23	25.35	25.47	25.59	25.71	25.83	25.95	26.07	26.19	26.31
2.2	26.43	26.55	26.67	26.79	26.91	27.03	27.15	27.27	27.39	27.51
2.3	27.63	27.75	25.87	27.99	28.11	28.23	28.34	28.46	28.58	28.70
2.4	28.82	28.94	29.06	29.18	29.30	29.42	29.54	29.66	29.78	29.90
2.5	30.02	30.14	30.26	30.38	30.50	30.62	30.74	30.86	30.98	31.09
2.6	31.21	31.33	31.45	31.57	31.69	31.81	31.93	32.05	32.17	32.29
2.7	32.41	32.53	32.65	32.77	32.89	33.00	33.13	33.25	33.36	33.48
2.8	33.60	33.72	33.84	33.96	34.08	34.20	34.31	34.43	34.56	34.68
2.9	34.79	34.91	35.04	35.16	35.27	35.39	35.51	35.63	35.75	35.87

The osmotic pressure corresponding to depression of hundredths of degrees may be read directly from the table. Furthermore, for all practical purposes the first differences x 0.1 may be taken as 0.012; hence, pressure when $\triangle$ is read to thousandths of a degree may be at once determined. Thus, suppose $\triangle$ to be 1.244. For $\triangle = 1.24°$ $P = 14.92$ atmospheres; $4 \times 0.012 = 0.048$; 14.920 plus 0.048 = 14.968, total osmotic pressure in atmospheres.

The lowering of the freezing point of the various soils then at the two opposite moisture contents together with the calculated concentration in p. p. m. of solution and the osmotic pressure in atmospheres that these values of the freezing-point depression represent, are shown in Table 3:

Table 3. Freezing point lowering and the corresponding concentration and the osmotic pressure of various types of soil at low and high moisture contents.

	Heavy silt loam (1).		Heavy silt loam (2).		Heavy silt loam (3).		Light silt loam (4).		Heavy silt loam (5).		Light clay loam (6).	
Percentage of Moisture	16.64	38.30	17.08	40.65	14.22	38.46	12.65	38.67	13.45	38.22	11.54	32.50
Freezing point depression	1.370	.007	1.010	.020	1.120	.025	1.170	.038	1.200	.029	1.090	.022
Parts per million	33,415	171	24,636	488	27,320	610	28,540	927	29,270	707	26,590	537
Osmotic pressure	16.48	.084	12.16	.241	13.48	.301	14.08	.458	14.44	.350	13.12	.265
	Heavy silt loam (7).		Very light silt loam (8).		Light silt loam (9)		Heavy sandy loam (10).		Fine sandy loam (11).		Sand (12).	
Percentage of moisture	7.00	26.53	11.28	32.37	13.30	38.45	11.15	32.13	6.89	26.46	2.43	20.27
Freezing point depression	1.100	.029	.900	.025	1.000	.018	.800	.046	.890	.030	.380	.015
Parts per million	26,830	707	21,950	610	24,390	439	19,510	1,122	21,710	732	9,268	366
Osmotic pressure	13.24	.350	10.84	.301	12.01	.217	9.635	.554	10.72	.362	4.58	.181
	Light sandy loam (13).		Texas, Houston black clay (14).		Texas Crawford clay. (15).		Texas brownish black loam (16).		Texas black sandy loam (17)		Texas Norfolk sandy loam (18).	
Percentage of moisture	7.20	20.33	21.97	42.42	18.29	33.90	11.38	27.63	9.87	27.73	3.53	16.37
Freezing point depression	.590	.053	.748	.054	.455	.060	.608	.038	.128	.040	.273	.058
Parts per million	14,390	1,293	18,246	1,317	11,100	1,463	14,830	927	3,122	976	6,658	1,415
Osmotic pressure	7.108	.639	9.009	.651	5.483	.724	7.325	.458	1.434	.482	3.291	.700
	Texas fine sandy loam (19).		Washington heavy silt loam (20).		Washington fine sandy loam (21).		Washington silt loam (22)		Washington clay loam (23).		Washington fine sand (24).	
Percentage of moisture	3.48	16.88	14.03	14.70	9.00	33.83	10.60	32.17	12.78	32.59	8.00	31.72
Freezing point depression	.293	.028	.903	.045	1.245	.028	1.253	.025	.820	.048	1.450	.187
Parts per million	7,146	683	22,020	1,098	30,370	683	30,560	610	20,000	1,171	35,370	4,561
Osmotic pressure	3.532	.338	11.20	.542	1.552	.338	15.40	.301	9.875	.579	17.44	2.255
	Washington Sand (25).		Wisconsin Superior clay (26).		Wisconsin Carrington silt loam (27).		Wisconsin Carrington silt loam. (28).		Wisconsin Miami silt loam (29).		Wisconsin Miami silt loam (30).	
Percentage of moisture	4.44	24.10	18.85	39.40	12.52	32.74	11.36	31.86	8.86	36.07	7.21	30.41
Freezing point depression	.630	.116	1.200	.017	11.248	.043	.689	.035	.802	.029	1.080	.029
Parts per million	15,370	2,829	29,268	415	30,440	1,049	16,800	854	19,560	707	26,340	707
Osmotic pressure	7.590	1.399	12.28	.205	14.80	.518	8.300	.422	9.659	.350	13.00	.350
	Wisconsin Colby silt loam (31).		Wisconsin Plainfield F. S. (32).		Minnesota clay (33).		Minnesota sandy loam (34).		Minnesota sand (35).		Pennsylvania silt loam (36)	
Percentage of moisture	12.10	37.98	5.00	24.65	22.39	39.83	11.54	34.21	4.62	24.44	8.43	32.82
Freezing point depression	.863	.025	.260	.015	.987	.075	.969	.019	.433	.023	.900	.025
Parts of million	21,050	610	6,342	366	24,070	1,829	23,630	463	10,560	561	21,950	610
Osmotic pressure	10.72	.301	31.34	.181	11.56	.904	11.56	.229	5.218	.277	10.84	.301
	Pennsylvania silt loam (37).		Pennsylvania silt loam (38)		Pennsylvania silt loam (39)		Rhode Island sandy loam (40)		Rhode Island sandy loam (41)		Kentucky Carrington clay loam (42)	
Percentage of moisture	7.68	33.18	10.16	34.42	8.72	33.87	9.62	37.07	9.96	34.12	39.28	92.76
Freezing point depression	.995	.025	.690	.030	.870	.020	.620	.055	.940	.020	1.075	.039
Parts per million	24,270	610	16,830	732	21,220	488	15,120	1,342	22,930	488	26,220	951
Osmotic pressure	11.98	.301	8.312	.362	10.48	.241	7.469	.663	11.32	.241	12.94	.470

Table 3.—Concluded.

	Kentucky Marshall silt loam (43)		Kentucky Miami silt loam (44)		Kentucky Carrington loam (45).		Kentucky LaCrosse silt loam (46)		Florida Prairie sand (47).		Florida Prairie sand (48).	
Percentage of moisture	14.37	37.89	6.98	25.48	15 26	38.48	8.23	24.86	4.00	24.06	5 23	23.98
Freezing point depression	.785	.021	.640	.031	.672	.019	.423	.044	.290	.022	.110	.029
Parts per million	19,150	512	15,610	756	16,390	463	10,320	1,073	7,073	537	2,683	707
Osmotic pressure	9.454	.253	7.710	.374	8 095	.229	5.098	.530	3.496	.265	1.329	.350

	Florida Prairie sand (49).		Cal. Chino silt clay loam (50).		California Ramona clay loam (51).		California Holland loam (52).		Cal. Hartford fine silt loam (53).		California Galo fine silt loam (54)	
Percentage of moisture	5 16	22 45	22.46	37.26	17 52	30.11	8.79	25.14	7.09	25.42	6.87	19.65
Freezing point depression	.183	010	.920	.089	.667	.060	.763	.013	.200	.025	.242	.025
Parts per million	4,463	214	22,440	2,171	16,270	1,463	18,610	317	4,878	610	5,902	610
Osmotic pressure	2.207	.121	11.08	1.073	8.035	.724	9.190	.157	2.412	.301	2.917	.301

	Cal. Oakley fine silt loam (55).		Quartz sand (56).		Muck (57).		Peat (58).	
Percentage of moisture	7.68	16.28	1.50	15.0	75 07	134.39	61.28	203 54
Freezing point depression	.399	.028	.070	.007	.470	.048	.420	.040
Parts per million	9,731	683	1.705	.170	23,500	2,400	23,333	2,222
Osmotic pressure	4.809	.350	.841	.034	5.661	.578	5 062	.482

The data presented in the above table agree exactly with the similar results obtained in the first investigation. They show (1) that the lowering of the freezing point of soils is entirely different at the opposite moisture contents in all the different soils; (2) the degree of the depression is rather small at the high moisture content and varies quite appreciably in the different soils, while at the low moisture content it is tremendously high and varies considerably in the various soils. At the high moisture content the lowering of the freezing varies from .010°C in the case of sands to .075°C in the case of some clay loams and clays, while at the low percentage of moisture it ranges from about .110°C in some of the sands to about 1.370°C in some of the loams and clays. The degree of depression for heavy sandy loams, silt loams, clay loams, and clays tends to be above 1°C at the minimum water content, while that of sands and very light sandy loams lies as a rule close to 0.4°C. The percentage of moisture of the quartz sand, many of the sands, and light sandy loams at the minimum water content at which these small depressions were obtained is extremely low, only a little above the hygroscopic point. Thus, the percentage of moisture of the quartz sand and one of the sands is only 1.5 and 2.43 respectively. Yet at this extremely low water content the quartz sand gave a depression of only .070°C and the sand .380° C. While the percentage of water in the loams, silts, and clays at the minimum percentage of water at which the great depressions were obtained, is comparatively very high. Thus, the Kentucky Carrington clay loam and the Minnesota clay contain 39.28% and 22.39% of moisture respectively. Yet at this apparently high moisture content the lowering of the freezing point of the Kentucky Carrington clay loam is 1.075°C and that of the Minnesota Clay .987°C.

The significance of the differences in the moisture content and the

corresponding depressions between the light and heavy types of soil will be revealed subsequently. In the meantime the reader is warned not to conclude that the variation in the depression between the different types of soil and especially between the closely related types signifies absolute difference in total salt content. This is on account of the fact that the free moisture content of the different soils is probably not exactly equivalent, and free water, as will be subsequently seen, is one of the controlling factors in the freezing point lowering.

The degree of concentration in parts per million of solution and of osmotic pressure in atmosphere is also very different at the two moisture contents and in all soils, which, of course, is quite natural. At the high moisture content the concentration varies from 366 p. p. m. in the case of sand (Soil No. 12) to 1829 p. p. m. in clay (Soil No. 33). The osmotic pressure in the same soils range from .181 to .994 atmospheres in the sand and clay respectively. At the low percentage of moisture the concentration ranges from 9268 p. p. m. in the case of sand (soil No. 12) to 33,415 p. p. m. in the heavy silt loam (soil No. 1). The osmotic pressure for the same soils is 4.58 and 16.48 atmospheres for the sand and silt loam respectively.

The data in Table 3 also reveal the remarkable fact which was observed in the original investigation, namely, the lowering of the freezing point increases in all soils with the exception of quartz sand and possibly of some of the extreme types of sand, at a far greater rate than the percentage of water decreases. In other words the ratio of the freezing-point depression and of the percentage of water are not inversely proportional (approximately) as might be expected, save only in the quartz sand and some of the sands. Thus, Minnesota clay (Soil No. 33) at 39.83% of moisture gave a depression of .075°C and at 22.39%, .987°C, the ratio of the percentage of water at the low and high moisture contents is only 1.78 while that of the depression is 13.16. Kentucky Carrington clay loam (Soil No. 42) which at 92.76% of moisture produced a lowering of the freezing point of .039°C while at 39.28%, 1.075, shows a ratio of 2.37 in percentage of water and 27.56 in the lowering of the freezing point. In the case of the quartz sand, however, the ratio of the depression is directly inversely proportional to the water content. Thus, at 1.5% of water the depression is .070°C and at 15%, .007°C, the inverse ratio, therefore, being 10 to 10 respectively. Apparently the quartz sand yields entirely different results from those of the soils, especially the heavier types.

MATHEMATICAL LAW WHICH THE FREEZING-POINT LOWERING OF SOILS AT DIFFERENT MOISTURE CONTENTS FOLLOWS.

In the first investigation it was discovered that the results of both the quartz sand and of the soils followed distinct and definite mathematical laws. The results of the quartz sand and sands could be mathematically expressed by the simple equation $M \cdot D = K$, where K is a resultant contant, M the percentage of moisture content and D, the observed depression of the freezing point. While the results of the other soils followed an entirely different mathematical law and indeed the geometric progression law. That is, the lowering of the freezing point of the soils increased in a geometric progression while the percentage of water de-

creased in an arithmetic progression. The results of the soils, therefore, could be mathematically expressed by the equation $D = A \cdot R^{n-1}$, where D is the depression of the freezing point, A the first depression, R the ratio of any depression (except the first) to the preceding one, and n the number of the depression. According to this formula, if the lowering of the freezing point of a soil was experimentally determined at two different moisture contents, it could be calculated for any other moisture content.

This phase of the original investigation was also restudied in the present work. As in the former case the procedure consisted of preparing a large number of samples of soil at different moisture contents, allowing them to stand in room temperature over night, care being taken to prevent evaporation, and then determining their lowering of the freezing point in the usual way. The quantity of moisture added was increased by equal amounts and the sample was prepared as rapidly as possible so that there would be the least possible loss of water through evaporation. The results obtained for quartz sand and for a few types of soil are represented in Tables 4 and 5, respectively.

Table 4. Lowering of the Freezing Point of Quartz Sand at Various Moisture Contents.

Percentage of Moisture.	Observed lowering of the freezing point. °C	Constant K.
2	.091	.182
6	.027	.162
10	.018	.180
14	.012	.168
18	.009	.162

Table 5. Lowering of the Freezing Point of Various Types of Soils at Different Moisture Contents.

Humus Loam.			Clay Loam.		
Percentage of moisture.	Observed lowering of the freezing point. °C	Calculated lowering of the freezing point. °C	Percentage of moisture.	Observed lowering of the freezing point. °C	Calculated lowering of the freezing point. °C
10	1.473	....	10	1.226	....
12	.970	.921	12	.928	1.161
14	.580	.608	14	.583	.8790
16	.440	.3625	16	.374	.5522
18	.245	.275	18	.283	.3543
20	.203	.1531	20	.209	.2681
22	.167	.1269	22	.175	.1980
24	.128	.1044	24	.138	.1658
26	.096	.080	26	.099	.1307
28	.068	.060	28	.065	.0938
30	.043	.0425	30	.048	.0616
32	.025	.0268	32	.043	.0455
34	.016	.0156	34	.038	.0407
36	.010	.010	36	.036	.036
38	.006	.00625	....	....	....
	Silt Loam.			Sandy Loam	
16	.850	....	7.0	.370	....
18	.530	.7420	9.0	.215	.2835
20	.321	.4846	11.0	.132	.1612
22	.202	.2802	13.0	.088	.0990
24	.092	.1763	15.0	.063	.0660
26	.077	.0831	17.0	.041	.0472
28	.071	.0672	19.0	.032	.0307
30	.062	.06198	21.0	.024	.0240

Considering first Table 4 which contains the results of the quartz sand it will be seen that by multiplying the percentage of moisture by its corresponding depression a constant or factor is obtained which is remarkably the same for all percentages of water content. These results of the quartz sand, therefore, follow the mathematical law of inverse proportionately and confirm entirely the results and conclusions of the first investigation.

It should also be recorded that a similar constant is obtained even when the quartz sand is treated with a salt solution, allowed to dry, and then its depression determined at different moisture contents.

Examining next Table 5 which contains the typical datat obtained in soils, it will be at once observed that these results are entirely different from those of the previous table. In the first place they do not follow the inverse proportionality law but the geometric progression law, that is, the lowering of the freezing point increases in a geometric progression as the water content decreases in an arithmetic progression. The closeness with which the results follow this law can be judged by comparing the observed and calculated depressions. The calculated values were obtained by dividing the last observed depression in each soil by the one preceding and then multiplying the various observed depressions by the ratio or constant thus obtained. A comparison of the two columns immediately shows that the calculated values agree quite closely with the observed ones. This close agreement is really remarkable considering the nature of the soil medium. Those cases where the disagreement is

quite appreciable are due to the variation in the moisture content. Although the successive increament of water added to the same amount of soil were accurately measured, yet during the preparation of the sample the loss of water that occurred, was undoubtedly not exactly equal in all cases. At the lower magnitude of moisture content small inequalities in percentage of water make tremendous differences in the depressions. It is not surprising, therefore, to obtain the most marked disagreement between the observed and calculated values at the lowest percentages of water content. Since these results, therefore, follow the geometric progression law, the similar data and conclusions in the first investigation also stand confirmed.

This second investigation, like the first one, has shown thus far, therefore, that: (1) at a very low moisture content the lowering of the freezing point is extraordinarily high and quite different in the various types of soil, being lowest in the sandy types and highest in the clayey types; (2) at very high moisture content, however, the freezing-point depression is relatively very small and appreciably different for the diverse classes of soil; (3) in all the different soils with the exception of quartz sand and possibly of some extreme types of sand, the depression of the freezing point increases in a geometric progression while the percentage of water content decreases in an arithmetic progression; in the case of quartz sand, however, the depression increases directly proportionally as the percentage of water decreases; (4) the magnitude of concentration in p. p. m. and of osmotic pressure in atmospheres that the lowering of the freezing point represents at the low moisture content are tremendously high, especially in the complex types of soil, but at the high water content, they are comparatively low.

It will at once be admitted, therefore, that these results appear extremely unusual and in some respects almost incredible, and do not harmonize entirely with the present views concerning the concentration of the soil solution. It is almost universally believed, for instance, that the soil solution of the average ordinary soils is very dilute, and according to some investigators it is not only very dilute but its magnitude of concentration tends to be constant and to remain the same for practically all soils. The foregoing results, however, as already seen, diametrically oppose these views.

The unusual rapid increase of the depression with the decrease in the percentage of moisture content and the extraordinary high lowering of the freezing point at the minimum degree of water content, created some doubts as to whether these depressions were really caused by the concentration of the soil solution and not by some physical factor or factors. If they were caused by some physical factors they do not represent of course concentration of solution. Two physical factors which might produce such results were suggested: (1) the supposed pressure with which the water films are held by the soil particles; and (2) the effect of the solid particles upon the freezing-point lowering. As to the first factor it was thought that since pressure is known to lower the freezing point of water, and if the pressure of the water films increased with the decrease in the moisture content, then the depression of the soils would be correspondingly increased. As to the second factor it was thought that possibly the solid particles themselves might influence the depression of the soils.

It must be stated at once that a thorough experimentation and a critical theoretical examination of both these factors have failed to indicate that they are the causal agents of the results noted. Some of the evidences both experimental and theoretical which bear out very strongly this conclusion may be mentioned as follows: (1) The data in Table 5 show that the depression increases in a geometric progression as the percentage of water decreases in an arithmetic progression, consistently and uniformally from the highest to the lowest water content. Now if the pressure of the films influenced the depression the rate of increase should not be the same, but entirely different, since the pressure of the films does not begin to be manifested until the moisture content is considerably reduced. Probably there should be a rather abrupt change in the results at the point where the water is reduced almost entirely to the film water.

(2) If the pressure of the films influences the freezing point lowering of soils at the low moisture content, it should affect it also at the high moisture content because after the free water is solidified the remaining water exists in films just as in the low moisture content and the effect would more or less constant in both cases.

(3) There are abundant evidences which go to indicate that when the soil mass is sufficiently supercooled and the water begins to freeze the physically adsorbed water freezes like free water, if it freezes at all, and the forces which hold the water do not influence the lowering of the freezing point. If pressure or the allied forces influence the depression at all, it is in causing some of the water in the soil to become unavailable or inactive, and thus not be in a free condition to act as a solvent and take part in dissolving the salts of the soil. This question, however, will be dealt with more in detail subsequently.

(4) The solid particles themselves do not influence the freezing-point depression as proved from the following evidences: (a) The lowering of the freezing point of very dilute soil suspensions is practically insignificant. (b) The freezing-point lowering of colloids is also so small as to be negligible. Indeed one of the characteristic properties of colloids, which distinguishes them from the crysalloids, is that they produce practically no depression of the freezing point. (c) The depression of a solution such as n/10 $NaNO_3$ determined in pure quartz sand is almost identical with that obtained in the solution itself. Thus the freezing-point depression of n/10 $NaNO_3$ solution alone was .370°, that of the solution with quartz sand .368°C or a difference of only .002°C.

(5) The washed quartz which *a priori* would not be expected to contain a solution of high concentration gave a depression of only .070° C. at 1.5% moisture, while clay loam which *a priori* would be expected to possess a solution of very high concentration gave a depression of 1.075°C at 39.28% of moisture.

There are still other evidences which could be brought forward to support the view but the foregoing may be considered sufficient.

The conclusion seems to be inevitable, therefore, that the unusual and significant lowerings of the freezing-point noted are caused by and represent actual concentration of solution, and therefore contradict the views held that the soil solution is very dilute, that its magnitude of concentration tends to remain constant, and to be the same for all soils.

AN HYPOTHESIS TO EXPLAIN THE INCREASE OF THE DEPRESSION WITH THE DECREASE IN THE WATER CONTENT.

No definite and proved theory was offered in the first investigation to explain the great increase in concentration of the soil solution with the decrease in moisture content. An hypothesis, however, which appeared to explain the phenomenon quite satisfactorily was tentatively offered. This hypothesis has been carefully considered and critically examined in the second investigation and it still appears to present the best explanation for the phenomenon under consideration, and consequently it is re-offered here in practically its original form.

In this hypothesis it is assumed that the soil solution contains salts or their ions produced by the reaction of the dissolved components of the soil minerals, hydrolysis of the minerals, application of fertilizers, decomposition of the organic matter, etc. These salts have as a rule a high solubility and would require a large amount of them to form a saturated solution. They are formed rather slowly and since the frequent rains, especially in the humid regions, tend to leach them away only a relatively small amount of them is present at a time. At a high moisture content these salts are greatly diluted and the lowering of the freezing point is small. As the moisture content, however, is reduced they are concentrated and the freezing-point depression becomes greater. Since they are present only in relatively small quantities, they do not form a saturated solution, at least many of them do not.

A critical consideration of the character of the soil system and a thorough examination of the available general data of the soil solution as obtained through soil water extracts, drainage water and other studies, lend considerable support to the above hypothesis.

A consideration of the soil mass shows that it is a heterogeneous mixture composed of solids, gases, and a liquid and inhabited by living organisms. The solid portion, in normal soils, is composed of mineral debris and organic matter, from rock and from animal and plant degredation and decomposition, respectively. Both of these classes of solid matter are gradually being reduced to the liquid state. The organic matter, for instance, mainly through the activities of the living organisms, is rendered soluble, and many organic and inorganic compounds are formed, including the nitrates, humic acids, etc. The nitrates may exist as $NaNO_3$, $Ca(NO_3)_2$, $Mg(NO_3)_2$, etc., depending upon the preponderance of the base present to unite with the acid radical. These nitrate salts have a very high solubility constant and to form a saturated solution a very large amount of them is required. Thus, to form a saturated solution at 20°C would require 83.7 grams of $NaNO_3$, 31.6 grams of $Mg(NO_3)_2$, and 54.8 grams of $Ca(NO_3)_2$ in 100 c. c. of water. It is doubtful, therefore, whether a normal soil and especially under humid conditions ever possesses a saturated solution in respect to these salts. Assuming, therefore, that there is a certain amount of nitrate salts present in the soil solution it naturally follows that at a high moisture content it is diluted, and as the percentage of water is reduced it becomes more concentrated, hence the lowering of the freezing point would tend to increase from the high to the low water content.

The dissolution of the mineral matter is accomplished by the solvent action of water aided by the foreign substances that it may be charged with—such as acids, bases, salts, etc. The soil minerals, however, are as a rule but slightly soluble and their rate of solution is generally very

slow, so slow indeed that it requires months, at least with certain minerals to form a saturated solution. Many if not all of the common soil-forming minerals, however, undergo hydrolysis and thereby increase their degree and rate of solubility. Their solubility may be further increased by the addition of soluble compounds yielding non-common ions, or by their reacting with some of the minerals to form new compounds, or by the dissolved components of the different minerals acting upon one another to form new compounds. Finally, the reduction of the soil particles into finer division both by climatic weathering and by artificial management increases the amount of material that goes into solution

Through these processes of hydrolysis, chemical reaction between applied salts and soil minerals, the reaction of the dissolved components of the different minerals, etc., probably there are formed in the soil solution salts of high solubility.

In the analysis of soil water extracts, drainage waters, etc., there are found, besides the NO_3 acid radical, the acid radicals HPO_4, SO_4, HCO_3, Cl, SiO_3, etc., and the base radicals Na, Mg, Ca, K, Al, Fe, etc. These acids and bases could well combine to form such compounds, for instance, as $CaH_4(PO_4)_2$, Na_2HPO_4, K_2HPO_4, $NaHCO_3$, $Mg(HCO_3)_2$, $CaSO_4$, Na_2SO_4, NaCl, KCl, $CaCl_2$, $Al_2(NO_3)_3$, $AlCl_3$, $Al_2(SO_4)_3$, $Fe(NO_3)_2$, $FeCl_3$, $FeSO_4$, etc.

That such compounds are formed and do exist in the soil to a greater or less extent can hardly be doubted. Both direct and indirect evidences strongly support the assumption. For instance, in those regions where the rainfall is small and the amount of leaching is consequently slight, such as in the arid regions, there is an accumulation of soluble salts near or at the surface of the soil, transported from below by the evaporation of the soil water. Such an accumulation of salts is designated as alkali conditions. Similar alkali conditions would doubtless occur even in the humid regions were it not for the excessive and frequent rains which tend to wash away these soluble salts, and thus prevent their accumulation. The soluble salts found wherever alkali conditions exist vary in number and composition. Table 6 which has been prepared by Lyon, Fippin, and Buckman (7), shows the kind and percentage composition of alkali salts in soils.

Table 6. Kind and Percentage Composition of Alkali Salts in Soils.

	Colorado Exp't Station.	California (Tulare) Exp't Station.	Yakima, Wash. 12-24 in.	Billings Crust.	Mont. Surface.	Yuma Crust.	Ariz. 0-72 in.
KCl	1.64		5.61			4.00	22.10
K_2SO_4		3.95		1.60	21.41		
K_2CO_3			9.73				
Na_2SO_4		25.28		85.57	35.12		
$NaNO_3$	33.07	19.78					
Na_2CO_3		32.58	13.86		7.28		
NaCl	6.61	14.75		.55		81.15	13.77
Na_3HPO_4	2.25						
$MgSO_4$				8.90	4.06		6.88
$MgCl_2$	12.71					7.71	3.98
$CaCl_2$	17.29					0.25	
$NaHCO_3$			36.72	0.67	22.06	0.28	21.02
$CaSO_4$	21.48		1.87	2.71	10.07	6.61	32.25
$Ca(HCO_3)_2$			16.48				
$Mg(HCO_3)_2$			15.73				
$(NH_4)_2CO_3$		1.41					

(7) Lyon, Fippin and Buckman. Soils, Their Properties and Management, p. 393, 1915.

It is evident from the above table that common salts of very high solubility do occur in the alkali soils.

Now if it has been proved absolutely that the salts in the above table do occur in the soils of the arid region, then there is no reason whatever why they should not occur also in the humid regions, but only in very small quantities of course. The only chief and important difference between the humid and arid regions is climatic, the chemical composition of the soils of both regions does not vary so greatly. In the humid regions there are few cases known where seemingly alkali conditions exist. The composition of the salts which form the alkali conditions consists in some of the cases reported (8) of $NaNO_3$, KNO_3, $Mg(NO_3)_2$ $Ca(NO_3)_2$, $CaSO_4$, $CaCl_2$, $Ca(HCO_3)_2$, $Mg(HCO_3)_2$, Na_2SO_4, etc.

That salts of high solubility may exist in the soil solution is further confirmed by the reaction that is conceived to take place between the soil and a soluble salt added. Thus, Al_x, Fe_x, Mg_x, Na_x, $Ca(SiO_3)_x$, $(H_2O)_x + 2KCl = Al_x$, Fe_x, Mg_x, Na_x, $K_2(SiO_3)_x(H_2O)_x + CaCl_2$. The $CaCl^2$ is assumed to be in solution.

The evidences, therefore, of the existence of salts of high solubility in the soil solution are overwhelmingly strong.

The solubility of some of the salts which are likely to occur in the soil solution was presented in the original report. For convenience and immediate usefulness they are repeated herewith:

Table 7. Solubility of Various Salts at about 20°C.

Name of Salt.	Grams of Salt dissolved in 100 Gm. water.
$NaNO_3$	83.7
KNO_3	31.6
$Ca(NO_3)_2$	54.8
$Mg(NO_3)_2$	42.33
KCl	34.07
$NaCl$	35.82
$CaCl_2$	74.00
K_2SO_4	11.11
$CaSO_4$	....
$MgSO_4$	36.2
$Ca(HCO_3)_2$	....
$Mg(HCO_3)_2$	....
$NaHCO_3$	9.60
$CaH_4(PO_4)_2$	....
$(NH_4)_2SO_4$	75.4

It is very evident that the solubility of most of the salts in the list is very high.

Since the formation of these salts is comparatively slow, and their accumulation to any appreciable extent is prevented by the excessive and frequent rains in the humid regions, their amount in the soil solution is relatively small and does not form a saturated solution, probably not even at a low moisture content. Those salts, of course, that form a saturated solution are separated in the solid phase. At the high moisture content, therefore, these salts are diluted and cause only a small lowering of the freezing point but as the water content is reduced they become more concentrated and they produce a correspondingly greater lowering of the freezing point. That is exactly what the experimental

(8) See original report loc. cit.

results show. Hence, the experimental data agree almost perfectly with the hypothesis.

All evidences, therefore, are overwhelmingly in favor of the hypothesis offered to explain the increase of concentration of the soil solution with the decrease in the moisture content.

Although the results obtained can be explained very satisfactorily by the foregoing hypothesis, they can be explained just as satisfactorily by still another hypothesis. This hypothesis involves the assumption that the solubility product or constant of a soil substance is different when the material is in contact with water in the film than in the mass form. That is to say the solubility product of a substance such as CaO for instance is different when the water present exists in the film form than when it is in the mass form. As the film water varies, the solubility product also varies. Although this hypothesis is entirely contrary to the present views regarding the solubility constant of solid substances, yet it is not at all unreasonable when we consider that we have many powerful forces operative when the water exists in the film form which are not operative when the water exists in mass.

A POSSIBLE EXPLANATION FOR THE INCREASE OF THE FREEZING-POINT DEPRESSION IN A GEOMETRIC PROGRESSION WHILE THE PERCENTAGE OF WATER DECREASES IN AN ARITHMETIC PROGRESSION.

The foregoing hypothesis offered to explain the increase in concentration of the soil solution with the decrease in moisture content does not explain, however, why the lowering of the freezing point should increase in a geometric progression while the percentage of water decreases in an arithmetic progression and does not follow a direct inverse proportionality ratio (approximately), as might be expected.

In the first report no definite and proved explanation was presented for this phenomenon, but only a tentative hypothesis was suggested. This hypothesis has undergone a very thorough examination in the present investigation and it appears that its validity is proven, and it is here reoffered.

The hypothesis assumes that a portion of the water found in the soils is inactive and does not take part in dissolving the salts in the soil, and is removed from the field of action as far as the lowering of the freezing point is concerned. Under this assumption the increase of the freezing-point depression in a geometric progression as the percentage of water decreases in an arithmetic progression is explained as follows: If a clay soil, for instance, causes 15% of water to become inactive, and this clay at 39% of moisture produces a lowering of the freezing point of .075°C and at 22%, .987°C, then at the former moisture content there is 24% of water free or available to dissolve the salts in the soil, while at the latter water content there is only 7% available for the same purpose. It would be natural, therefore, that the depression of the freezing point would be many times greater at the low moisture content than at the high than would be expected from the difference of the total moisture content, just as the experimental data really indicate.

This hypothesis also assumes (and the assumption seems to have been proved) that the percentage of inactive water is greater at the low than at the high moisture content and tends to decrease from the former to the latter.

That part of the water added to the soil may become inactive or available and thus be removed from the field of action as far as the freezing-point lowering is concerned seems to be proved beyond any doubt. Some of the evidences that may be brought forward which tend to confirm this fact are as follows: (1) The lowering of the freezing point of the agricultural soils at the minimum water content decreases with successive freezings as will be shown subsequently. This decrease is taken to mean that the process of freezing produces a change in the physical condition of the soil, and thereby releases some of the inactive water. This released and free water goes to dilute the original soil water and thereby decreases the depression of the soil solution.

(2) As has been shown in a former paper (9) when to a soil like clay, for instance, is added a certain amount of water and this wet soil is placed to freeze in an expansion apparatus like the dilatometer, only part of the water added freezes, as measured by the amount of expansion; the remainder of the water added apparently is prevented by the soil from freezing. This phenomenon has been observed also by Foote and Blair (10) in hydroges such as aluminum, silica, iron, etc.

(3) Cameron and Gallagher (11), and Keen (12) in conducting experiments to obtain information concerning the laws governing the evaporation of water from soils, found that the amount of water evaporated per unit of time was practically the same from a high moisture content down to a certain point and then it began to decrease quite rapidly. From the point where the rate of decrease commenced and downward, the soil water showed a lower vapor pressure than the free water. This diminution in the rate of evaporation and the reduction in the vapor pressure are taken by us to indicate that the soil water was not free but existed in an inactive or unavailable form.

(4) The investigations of Briggs and Shantz (13), and those of a great number of other investigators on the wilting coefficient of soils, show that plants begin to wilt and die when the percentage of water in the soil is still considerable. Some investigators have attributed this phenomenon to the extremely slow movement of water in the soil at that low water content and consequently to the failure of the plants to obtain water at a sufficient rate to replenish that lost through evaporation and thus avoid wilting. We are inclined to attribute the wilting of plants partly also to their inability to absorb or extract the water which is held by the soil in an inactive or available form, at a sufficient rate.

(5) Jones (14) and his associates, working upon the lowering of the freezing point of various hydrates, found that these substances yielded far greater depression of the freezing point than should be expected. Jones attempted to explain these abnormal results by assuming that these hydrates take up water, forming complex compounds with it, and thus remove it from the field of action as far as the freezing point lowering is concerned.

Many other evidences could be cited which go to indicate that part of the water contained by the soils exists in an inactive or unavoidable form but the foregoing may be considered sufficient.

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(9) Jour. Agr. Res., v. 8, No. 6, 1917.
(10) Jour. Am. Chem. Soc., v. 38, No. 3, 1916.
(11) Bul. No. 50, Bu. Soils, U. S. Dept. Agr., 1908.
(12) Jour. Agr. Sci., 6, 1914.
(13) Bul. No. 230, Bur. Plant Ind., U. S. Dept. Agr., 1912.
(14) Jones H., Elements of Physical Chemistry, p. 238, 1910.

The question now is, in what particular form or forms does this inactive or unavailable water exist in the soil? It should be mentioned that this special subject is now under investigation and the final conclusions will be reserved for a subsequent paper. It might be mentioned here, however, that this inactive or unavailable water appears to exist both as physically adsorbed water and as loosely chemically combined water with the latter probably predominating. In both cases the water is conceived to exist practically in a solid state like water of crystalization.

The foregoing hypothesis, therefore, would tend to explain, at least partially, why the lowering of the freezing of soils, with the exception of quartz sand and possibly of some extreme types of sand, should increase in a geometric progression while the percentage of water decreases in an arithmetic progression. It would also tend to explain why the freezing-point lowering of the quartz sand should increase inversely proportionally with the water content, which would tend to indicate that quartz sand causes very little if any of the water added to become inactive or unavailable. That the latter fact might be so is further shown by the solidification which can be induced when the moisture content is only 0.7% or practically at absolute dryness. It should be stated, however, that even quartz sand under certain conditions, may cause some of the water to become inactive, the amount, however, is very small.

THE SIGNIFICANCE OF THE INACTIVE OR UNFREE WATER IN THE SOIL UPON VARIOUS DETERMINATIONS NOW IN VOGUE.

If the soils cause some of the water to mecome inactive or unfree and the amount varies with the kind of soil, then the results obtained by some methods now in vogue are not really and justly comparable. Thus, for instance, take the results obtained from soil water extracts as prepared by mixing soil and water in certain definite proportions. If the extracts are made from various types of soil and these types of soil cause different amounts of water to become inactive or unfree and thereby lose its solvent action, then the soils are really extracted not by the same amounts of water but by entirely different quantities. The result will be that the concentration of the extracts will vary not entirely according to the total soluble material present but also according to the amount of water which acted as a solvent.

The validity and force of these statements are most strikingly illustrated by the data presented in Table 8. These data were obtained by mixing 20 grams of air dry soil with 4 c. c. of water and then determining the lowering of the freezing point in the usual manner. This procedure is really and purposely an imitation of the method widely used by mixing 100 grams of soil with 500 c. c. of water and then ascertaining the concentration of the extract.

Table 8. The Lowering of the Freezing Point of Soils to which were Added 4 c.c. of Water to 20 Grams of Soil.

		Freezing point depression.	Total percentage of moisture.
1.	Heavy silt loam	.312°C	23.31
2.	Heavy silt loam	.440	24.24
3.	Heavy silt loam	.254	22.81
4.	Light silt loam	.220	22.59
5.	Heavy silt loam	.209	23.45
6.	Light clay loam	.207	21.76
7.	Heavy silt loam	.097	20.57
8.	Light silt loam	.152	24.37
9.	Heavy silt loam	.089	21.35
10.	Very light silt loam	.110	22.93
11.	Heavy sandy loam	.119	22.16
12.	Fine sandy loam	.074	19.86
13.	Sand	.017	19.35
14.	Light sandy loam	.054	20.50
15.	Pennsylvania silt loam	.119	20.98
16.	Pennsylvania silt loam	.109	21.37
17.	Pennsylvania silt loam	.107	21.39
18.	Pennsylvania silt loam	.111	21.10
19	Kentucky Carrington clay loam	1.245	29.31
20.	Kentucky Marshall silt loam	.131	22.78
21.	Kentucky Miami silt loam	.042	20.46
22.	Kentucky Carrington loam	.111	23.96
23.	Kentucky LaCrosse sandy loam	.060	20.00
24.	Texas Houston Black clay	.422	25.23
25.	Texas Crawford clay	.133	23.92
26.	Texas Brownish black loam	.031	22.23
27.	Texas fine sandy loam	.093	19.34
28.	Texas black sandy loam	.053	20.01
29.	Texas Norfolk sandy loam	.050	17.69
30.	Texas fine sand	.102	18.42
31.	Texas fine sandy loam	.035	17.24
32.	Washington heavy silt loam	.158	23.73
33.	Washington silt loam	.431	23.49
34.	Washington fine sandy loam	.078	22.02
35.	Washington silt loam	.088	22.96
36.	Washington clay loam	.138	22.77
37.	Washington silt loam	.300	21.41
38.	Washington silt loam	.110	22.68
39.	Washington sand	.115	20.11
40.	Florida Prairie sand	.017	19.54
41.	Florida Prairie sand	.017	19.43
42.	Florida Prairie sand	.011	19.74
43.	Wisconsin Superior clay	.392	25.08
44.	Wisconsin Carrington silt loam	.110	21.90
45.	Wisconsin Miami silt loam	.087	21.17
46.	Wisconsin Miami silt loam	.081	20.79
47.	Wisconsin Colby silt loam	.110	22.18
48.	Wisconsin Carrington silt loam	.107	22.20
49.	Wisconsin Plainfield fine sand	.019	19.91
50.	Minnesota clay	.776	23.79
51.	Minnesota sandy loam	.138	22.60
52.	Minnesota sandy loam	.061	22.84
53.	Minnesota sand	.018	18.88
54.	California Chino silty clay loam	.545	26.65
55.	California Ramona clay loam	.139	24.28
56.	California Holland loam	.016	21.07
57.	California Harford fine sandy loam	.028	20.69
58.	California Galo fine sandy loam	.023	19.76
59.	California Oakley fine sandy loam	.025	19.89
60.	Rhode Island sandy loam	.025	21.45

The foregoing results are really of the highest importance. They show that by employing the same amount of soil and the same quantity of water entirely different depressions are obtained in the diverse classes of soil. The magnitude of the depression ranges form .017 in the case of sand (Soil No .13) to 1.245 in the case of clay loam (Soil No. 19), or a difference of over 73 times. The variation between the other soils is not as great as this, but certainly sufficiently great.

If one were studying the comparative soluble salt content of the above list of soils and obtained the foregoing depressions of the freezing point

he would at once conclude that soil No. 19, for instance, contains 73 times more soluble salts than soil No. 13 at the arbitrary ratio of 5 of soil to 1 of water. Such a conclusion, however, would be entirely erroneous. Although soil No. 19 may contain more soluble salts than soil No. 13, but certainly not in the proportion indicated by the respective depressions. This tremendous difference in the lowering of the freezing point between the various soils is actually and mainly due to the different power of the various soils for causing water to become inactive or unavailable and consequently to the different amounts of free water acting as a solvent of the soluble material. In table 9 there are shown the relative amounts of water that some of the soils of the above list caused to become inactive or unavailable. These results were obtained by means of the dilatometer method (15). The principle of this method is based upon the fact that when water freezes it expands. Knowing the amount of expansion produced by a certain quantity of water, say one gram, then the total amount of water frozen can be easily calculated. The amount that is not frozen can be ascertained by difference. In the case of soils the amount of frozen and unfrozen water was ascertained as follows: To 25 grams of soil was added 5 c. c. of water. If all of this 5 c. c. of water froze in the soil the amount of expansion produced would be equal to that of 5 c. c. of water frozen alone. If only a fraction of the 5 c. c. added froze, then the quantity that did not freeze was ascertained by difference. In Table 9 the amount of the 5 c. c. of water that did not freeze and consequently remained as inactive or unfree and did not take part in dissolving the soluble material in the soil is expressed both in c. c. and in percentage. In the same table are repeated the lowering of the freezing point of the corresponding soils so that a direct and convenient comparison can be made of the amount of water that each soil caused to become inactive and the corresponding lowering of the freezing point. It will be noticed that the amount of soil and water employed is not the same in the two cases but the ratio is the same.

Table 9. Quantity of Water Caused by Various Soils to Become Inactive and the Corresponding Lowering of the Freezing Point.

Name of soil.	C.C. of the 5 c.c. of water failed to freeze.	Percentage of the 5 c.c. of water failed to freeze.	Lowering of the freezing point.
1. Quartz sand	.1	2.0	.009
2. Sand	.3	6.0	.074
3. Heavy silt loam	3.7	74.0	.440
4. Heavy silt loam	3.5	70.0	.312
5. Light clay loam	2.0	40.0	.200
6. Carrington loam	2.8	56.0	.111
7. Marshal silt loam	2.9	58.0	.131
8. Houston black clay	3.0	60.0	.422
9. Fine sandy loam	0.5	10.0	.093
10. Superior clay	3.5	70.0	.392
11. Painfield fine sand	0.4	8.0	.019
12. Sand	0.5	10.0	.018
13. Sand	0.5	10.0	.017
14. Sand	0.6	10.0	.011
15. Sandy loam	1.7	34.0	.138

(15) Jour. Agr. Res., v. 8, No. 6, 1917.

A thorough examination of the foregoing data reveals many exceedingly interesting and highly important facts. In the first place they show that the different soils caused entirely different amounts of water to become inactive or unavailable. Thus in the case of soil No. 1 or quartz sand only 2% of the 5 c. c. of water added failed to freeze while in soil No. 3 more than 70% of the 5 c. c. added failed to freeze, and consequently had been converted into an inactive or unfree form. It appears that sands and very light sandy loams caused the smallest amount of water to become inactive while the loams, silts, clays, and mucks, the greatest. In the second place the above data show that those soils which caused the least amount of water to be converted into unfree state produced the smallest lowering of the freezing point while those soils which caused the greatest quantity of water to become inactive produced the largest freezing-point depression. Thus soil No. 2 in which only 6% of the water added failed to freeze, the depression of the freezing point amounts only to .074°C, while in soil No. 3 in which more than 70% of the water added refused to freeze the depression amounts to .440°C or 6 times as great. In every case there is almost a perfect relation between the amount of water which failed to freeze and consequently had become inactive according to the dilatometer method, and the freezing-point depression.

It seems to be absolutely proven, therefore, that soils cause water to become unavailable or inactive and thereby lose its solvent action; that the amount varies with different soils, being smallest in sands and light sandy loams and greatest in clay loams, clays, mucks, and peats; and, that the water put out of action influences appreciably many determinations commonly made for comparative studies especially if the ratio of water to soil is not very large.

The ability of soils to cause water to become inactive or unavailable and to lose its solvent action, explains very readily why muck and peat with 200 or 300% of water at the high moisture content produce as much depression as the clays at only 40 or 50% of water.

EFFECT OF SUCCESSIVE FREEZINGS UPON THE LOWERING OF THE FREEZING POINT.

It was discovered at the very beginning of the first research that the lowering of the freezing point of some soils such as sands and light sandy loams, and of some artificial substances such as quartz sand, kaolin, burned silicic acid, etc., remained quite constant with successive freezings, but in soils such as sandy loams, loams, silts, clays, peats, etc., it varied with repeated freezings, and indeed it decreased with successive freezings up to a certain number of freezings and then it became constant. The magnitude of the change between the different soils could not be compared in the first report because the length of time and degree of super-freezing were not the same either within the same soils or in the different soils. In other words, the procedure was not uniform. The results in the first report were merely presented to show that successive freezings tend to diminish the lowering of the freezing point of some soils and not of others.

In the second or present investigation the effect of repeated freezing upon the lowering of the freezing point has been also reinvestigated, at this time more thoroughly and systematically and with more uniform procedure. The procedure consisted of determining the depression of soils at a very low moisture content in the usual way, and then placing the soil sample, without disturbing it, in a cooling mixture having a temperature of about —12°C, and allowing it to remain there for one hour. The sample then was taken out of the cooling bath, thawed by holding that portion of the tube containing the soil between the hands, and then determining the freezing-point depression again. Table 10 contains the results obtained by this procedure with only a few of the typical soils that were employed.

Table 10. Effect of Repeated Freezing upon the Lowering of the Freezing Point.

Quartz Sand.			Kaolin.		
Percentage of moisture.	Number of times frozen.	Lowering of the freezing point. °C	Percentage of moisture.	Number of times frozen.	Lowering of the freezing point. °C
2.0	1 2	.120 .120	39.5	1 2	.432 .430
Sand			**Sandy Loam.**		
2.43	1 2	.380 .350	7.20	1 2	.560 .520
Light Silt Loam.			**Heavy Silt Loam.**		
11.54	1 2	1.090 .960	17.08	1	1.010 .820
Heavy Silt Loam.			**Heavy Silt Loam.**		
16.64	1 2	1.370 1.030	13.45	1 2	1.200 1.000
Burned Heavy Silt Loam.			**Burned Silt Loam.**		
1.66	1 2	.095 .092	6.80	1 2	.630 .620

The foregoing results together with those announced in the first report prove absolutely that successive freezings effect the lowering of the freezing point differently in the various soils. In such soils as sand and very light sandy loam and artificial substances such as kaolin, quartz sand, etc., the depression is influenced very little, if any. With such soils as heavy sandy loams, loams, silts, clays, etc., the depression decreases and the magnitude of diminution varies with the character of the soil, it is smallest in the sandy types and reaches its maximum in the heavy silt loams. In the former types of soil the diminution in the depression amounts only to about 8% in some cases, while in the latter types of soil it amounts to more than 25%.

The question now is, what causes this diminution of the freezing-point depression with repeated freezings and why it occurs in the case of some soils or substances and not in others. An attempt will now be made to offer a possible explanation for this phenomenon.

It was once thought that the soil solution at the low moisture content employed reached its saturation point in concentration and as it cooled salts separated, for the solubility of salts diminishes of course with falling temperature, and thus the solution became less concentrated. This hypothesis, however, would not explain the continued decrease in the depression with repeated freezings for if the soil solution were concentrated to the saturation point at the low moisture content all the excess of salts should separate the first time it is cooled below 0°C, and inasmuch as probably not all of the separated salts would go again into solution upon thawing—owing to the short length of time—the concentration of solution and hence the lowering of the freezing point should remain more or less stationary. Hence this hypothesis fails to explain the results.

An hypothesis which appears to explain the results quite satisfactorily and which seems to be supported by a great amount of evidence is as follows: The greatest portion of the water which the soils cause to become inactive or unavailable and thus lose its solvent action is due to the colloids which the soils contain. This inactive or unavailable water may exist in the colloids both as physically absorbed water and as loosely chemically combined water. Upon freezing, their colloids coagulate and the bonds uniting them with the water break and the inactive or unavailable water becomes liberated. This liberated water becomes available or acts as a solvent and goes to dilute the original solution and thereby decreases the lowering of the freezing point. Thus, for instance, if there were only 5% of available moisture before the first freezing was made, there were probably 7% at the end of the first freezing, 7.5% at the end of the second freezing and so on until all or most of the colloids are coagulated. Or if the freezing is greatly prolonged at a very low temperature as was done in the second investigation, then probably all or most of the colloids are coagulated so that all the inactive water that would become available is liberated at once.

The foregoing hypothesis seems to find a large amount of confirmation from both direct and indirect evidences. It is now generally believed that there are present in soils both hydrosols and hydrogels consisting of organic substances, the humus compounds, and inorganic sub-

stances, the hydrogels of alumina, iron, manganese, hydrated silica, etc.; that the hydrosols are continually being produced in the soils by physical action such as that of water on clay, or by chemical changes such as the decomposition of silicates; and, that there are in nature various agencies such as changes in temperature, concentration of solution, etc., by which hydrosols are changed to hydrogels and vice versa. Both heating and freezing have been found to cause coagulation of the hydrosols and hydrogels and this coagulation is accompanied by a decrease in the absorptive power. It has been abundantly proven for example that when clay is heated its absorptive power for water is greatly diminished.

The foregoing hypothesis appears to be further confirmed by the following experimental data: (1) When some of the soils in Table 10 which show a large diminution in the depression upon refreezing were heated to red heat and then their depression was determined at a very low moisture content in successive freezings, it was found that the magnitude of the depression remained practically constant at successive freezings. The logical inference that may be drawn from these results is that heat coagulated or destroyed all the colloids and probably no uncoagulated colloids were left to be coagulated by freezing and thereby the inactive water to become available.

(2) When the same unheated soils as above were frozen in the dilatometer it was found that the amount of expansion in the second freezing was considerably greater than that in the first, indicating that there was a larger amount of free water to freeze in the second freezing than in the first. These results are considered by us to be an absolute proof that the process of freezing causes inactive water to become free or available.

The foregoing hypothesis, therefore, would seem to explain very well the diminution of the lowering of the freezing point of the agricultural soils at low moisture content with repeated freezings. It would apppear also to suggest that such substances as quartz sand, kaolin, burned soils, etc., either do not contain colloidal material or if they do it is not coagulable, and consequently not of the same nature as that of the agricultural soils. It might be, however, that these substances reabsorb the water made available during freezing, upon thawing. If that is the case then it would mean that freezing did not cause a permanent change in the physical condition of the substances, and consequently the above conclusion appears valid.

At the high moisture content coagulation of the colloids of the agricultural soils should also take place but since the percentage of water present is high and the soil solution is very dilute, the amount of water that is released upon coagulation is too small to make any noticeable effect upon the depression. Consequently, the duplicate determinations agree in soils with high moisture content, but do not with low water content.

DETERMINING THE WILTING COEFFICIENT OF SOILS BY THE FREEZING POINT METHOD.

It has already been mentioned that solidification cannot be started, at least very readily, below a certain moisture content. The percentage of this moisture content is quite definite and very different in the diverse classes of soil. It occurred to us that this point of water content where solidification refuses to take place might be the same as that where plants begin to wilt. In order to obtain information upon this interesting phase of the investigation the wilting coefficient of several soils was determined by following the method described by Briggs and Shantz (16), and using wheat as indicator. Several series of experiments were performed upon the subject. The results of one series which are typical of all the results, are shown in Table 11. In this table there are presented also the moisture contents at which solidification refuses to take place or at least very readily.

Table 11 Comparison of the Moisture Content of Soils where Solidification Refuses to Take Place and where Plants Begin to Wilt.

Nane of soil.	Percentage of water where solidification refuses to take place.	Percentage of water where plants begin to wilt.
Sand	2.10	1.49
Sand loam	6.7	5.28
Silt loam	10.3	9.62
Heavy silt loam	16.8	18.79
Heavy silt loam	16.00	17.16
Heavy silt loam	13.50	13.82
Sandy loam	5.60	4.87

By comparing the two columns it will at once be seen that the percentage of water content at which wilting of the plants occurred and the solidification refused to take place, agree remarkably. It will be noticed that in no case does the difference exceed more than 2%.

We confidently believe that the point where solidification refuses to take place marks an important transition in the state of the soil moisture and that this point is very close to the wilting coefficient of soils. Hence, we further believe that the freezing point method can be used to determine the wilting coefficient of soils and that such determinations will be more accurate and of course infinitely more convenient and rapid.

(16) Loc. cit.

THE SIGNIFICANCE OF THE GREAT CONCENTRATION OF SOLUTION AT THE LOW MOISTURE CONTENT UPON PLANT GROWTH.

If the tremendous depression of the freezing point as obtained at the low moisture content in many soils, really represents concentration of solution, then it throws new light upon several observed phenomena in plant growth. One of these phenomena is the wilting of plants. In the light of the extraordinary high depressions obtained at the low moisture content it would be only logical to conclude that one of the causes of the wilting of plants is due to the great concentration of the soil solution when the moisture content has been reduced to the wilting coefficient. This conclusion appears to be amply supported by the following facts:

(1) The depression of the freezing point of the complex types of soil at the wilting coefficient was considerably greater than that of the tops and roots of the wheat seedlings. Thus, the lowering of the freezing point of many silt loams, clay loams and clays was about 1.300°C while that of the tops was about 1.000°C and of the roots about .700°C. The above depression value of the soils represents an osmotic pressure of 15.64 atmospheres, that of the tops 12.04 atmospheres, and that of the roots 8.432 atmospheres. Hence, there is an appreciable difference in the osmotic pressure between the soils and the wheat seedlings, in favor of the soils. Since it has already been seen that the depression increases tremendously with extremely small decreases in the percentage of water at the low moisture content, the concentration of the soil solution 1 or 2% of moisture below the wilting coefficient would be far greater than the value shown above.

(2) The recent work of Shive (17) and of McCall (18) shows that plants both in tops and roots made the best growth when the initial concentration of the nutrient solution was about 1.75 atmospheres.

The high osmotic pressure of the soil solution at the wilting coefficient as indicated by the freezing point method is contrary to the results obtained by Shull. Shull (19) attempted to measure the force with which the soil moisture is held by the soil by means of Xanthium seeds. He found by this method that the total force with which the moisture is held by the soil or the "back pull" at the wilting coefficient of soils amounts only to about four atmospheres. Shull concludes, therefore, "that this critical soil moisture content must be due to the increasing slowness of water movement from soil particles to soil particles, and from these to the root hairs, the rate of movement falling below that necessary to maintain turgidity of the cells of the aerial parts, even under condition of low transpiration."

As already seen, the osmotic pressure of the soil solution alone amounts to about 15 asmospheres. Now as will be shown in a subsequent paper, the soil moisture at and below the wilting coefficient appears to exist as physically absorbed and loosely chemically combined and in a solid phase. The water, therefore, in this condition must be held by the soil with a considerable force. This force must be added that due to the concentration of the soil solution alone. The total force, therefore, with which the water is held back by the soil is many times greater than that obtained by the method of Shull.

(17) Am. Jour. Bot., 2, 157-160, 1915.
(18) Soil Science, 2, 207-253, 1916.
(19) Bot. Gaz., 62, No. 1, 1916.

THE FREEZING POINT METHOD AND THE FERTILITY OF SOILS.

It should be strongly emphasized that no claim is made that by means of the freezing point method the fertility of the soil can be determined. Such a claim would be almost absurd since the freezing point method indicates only concentration of solution and tells nothing of the chemical composition of this solution. A soil may possess a solution of high concentration and yet this concentration may be composed entirely of salts which do not contain the plant food elements.

What is claimed is that the freezing point method furnishes: (1), information concerning the concentration of the soil solution from any maximum moisture content to a very low water content.

(2) It tends to compare approximately the salt content or concentration of solution of soils and especially of the extreme types of soil, at an equivalent moisture content. This equivalent moisture content, however, is difficult to obtain as has been seen.

(3) It detects readily the abnormal concentration of solution of unusual soils. Thus, Director Hartwell had two soils in the green house which were heavily fertilized and were planted to carnations. The latter failed to make any satisfactory growth. Director Hartwell sent us samples of these soils to determine their lowering of the freezing point. The test showed that the depression of these soils at a high moisture content or at the saturation point was about .600°C or about 30 times as great as that of average soils. Unquestionably, therefore, the carnations refused to make a satisfactory growth on account of this great concentration of solution. Many similar experiences could be cited if space permitted.

(4) It shows the effect of application of fertilizers upon the concentration of the soil solution, as will be subsequently seen.

(5) It reveals a most remarkable relation between the soil and the water.

(6) It can be employed to determine the wilting coefficient of soils.

(7) It can be used to study the toxic effect of salt or the toxic effect of alkali soils, upon plant growth, as the toxic effect is due not only to the total soluble material present but also to the total concentration which is composed of total soluble material and ionization of this material.

All these facts are of the greatest importance in furthering our knowl edge concerning the fundamental principles governing the soil solution and undoubtedly that of the soil fertility.

EFFECT OF APPLICATION OF SOLUBLE SALTS UPON THE CONCENTRATION OF THE SOIL SOLUTION IN THE SOIL.

The effect of application of soluble salts upon the concentration of the soil solution was also reinvestigated in the second study. The investigation, however, was greatly extended by employing a greater number of salts and a larger number of soils. The soils numbered 67 as compared with 10 in the first investigation, and varied both in origin and type. They represented characteristic types of soil from 10 different states. In fact they were the same soils which were used to determine the concentration of their solution at very low and high moisture content already considered.

The procedure followed in the second investigation was the same as in the first and consisted of treating the soils with n/10 solution of different salt solutions, allowing them to stand in closed tubes at room temperature for about 24 hours and then determining their lowering of the freezing point. To each soil was added a sufficient amount of solution to bring it up to a very high moisture content, thus eliminating some of the errors that occur at the low moisture content, and the amount was exactly the same for all salt solutions for any one soil. For each treated soil there was always a check, having the same percentage of moisture, but made up only of distilled water. Great care was taken to mix each soil sample with the solution or water very thoroughly. The results obtained are detailed in Table 12:

Table 12. Effect of Soluble Salt Upon the Concentration of the Soil Solution in the Soil.

	n/10KCl					n/10NaNO3					n/10Ca(NO3)2				
	Depression of Solution alone.	Depression of Solution with Soil.	Difference.	Percentage of cnange in Depression.	Percentage of Original Concentr. of Salt Solution Went to Concentrate Soil Solution.	Depression of Solution alone.	Depression of Solution with Soil.	Difference.	Percentage of change in Depression.	Percentage of Original Concentr. of Salt Solution Went to Concentrate Soil Solution.	Depression of Solution alone.	Depression of Solution with Soil.	Difference.	Percentage of change in Depression.	Percentage of Original Concentr. of Salt Solution Went to Concentrate Soil Solution.
	°C	°C	°C			°C	°C	°C			°C	°C	°C		
1. Heavy silt loam	.370	.295	.075	20.27	**79.73**	.364	.305	.059	16.21	**83.79**	.280	.280	0	0	**100.0**
2. Heavy silt loam	.362	.272	.090	24.86	**75.14**	.359	.290	.069	19.22	**80.78**	.274	.278	−.004	−1.46	**101.46**
3. Heavy silt loam	.362	.268	.094	25.97	**74.03**	.359	.303	.056	15.60	**84.40**	.274	.260	.014	5.11	**94.89**
4. Heavy silt loam	.362	.280	.082	22.65	**77.35**	.359	.307	.052	14.49	**85.51**	.274	.272	.002	0.73	**99.27**
5. Light silt loam	.362	.282	.080	22.10	**77.90**	.359	.309	.050	13.93	**86.07**	.274	.269	.005	1.83	**98.17**
6. Heavy silt loam	.362	.278	.084	23.21	**76.79**	.359	.313	.046	12.81	**87.19**	.274	.276	−.002	−0.73	**100.73**
7. Light clay loam	.362	.309	.053	14.64	**85.36**	.359	.313	.046	12.81	**87.19**	.274	.278	−.004	−1.46	**101.46**
8. Heavy silt loam	.362	.300	.062	17.13	**82.87**	.359	.340	.019	5.29	**94.71**	.274	.285	−.011	−4.01	**104.01**
9. Light silt loam	.362	.282	.080	22.10	**77.90**	.359	.302	.057	15.88	**84.12**	.274	.275	−.001	−0.37	**100.37**
10. Heavy silt loam	.370	.318	.052	14.05	**85.95**	.364	.351	.013	3.57	**96.43**	.280	.300	−.020	−7.14	**107.14**
11. Very light Silt loam	.362	.275	.087	24.03	**75.97**	.359	.303	.056	15.60	**84.40**	.280	.260	.020	7.14	**92.86**
12. Heavy sandy loam	.362	.274	.088	24.31	**75.69**	.359	.313	.046	12.81	**87.19**	.280	.274	.006	2.14	**97.86**
13. Fine sandy loam (black)	.362	.305	.057	15.75	**84.25**	.359	.326	.033	9.19	**90.81**	.274	.275	−.001	−0.37	**100.37**
14. Sand (gray)	.362	.349	.013	3.59	**96.41**	.359	.364	−.005	−1.39	**101.39**	.274	.294	−.020	−7.30	**107.30**
15. Light sandy loam	.362	.320	.042	11.60	**88.40**	.359	.341	.018	5.01	**94.99**	.274	.287	−.013	−4.75	**104.75**
16. Penn. silt loam	.395	.295	.100	25.32	**74.68**	.373	.337	.036	9.65	**90.35**	.295	.252	.043	14.58	**95.42**
17. Penn. silt loam	.395	.296	.099	25.06	**74.94**	.390	.332	.058	14.87	**85.13**	.293	.265	.028	9.56	**90.44**
18. Penn. silt loam	.395	.292	.103	26.08	**73.92**	.373	.327	.046	12.33	**87.67**	.293	.262	.031	10.58	**89.42**
19. Penn. silt loam	.395	.304	.091	23.04	**76.96**	.373	.329	.044	11.80	**88.20**	.293	.264	.029	9.90	**90.10**
20. Kentucky Carrington clay loam	.395	.306	.089	22.53	**77.47**	.373	.310	.063	16.89	**83.11**	.293	.268	.025	8.53	**91.47**
21. Kentucky Marshall silt loam	.395	.291	.104	26.33	**73.67**	.373	.323	.050	13.40	**86.60**	.293	.283	.010	3.41	**96.59**
22. Kentucky Miami silt loam	.395	.297	.098	24.81	**75.19**	.373	.332	.041	10.99	**89.01**	.293	.277	.016	5.46	**94.54**
23. Kentucky Carrington	.395	.297	.098	24.81	**75.19**	.373	.302	.071	19.03	**80.97**	.293	.277	.016	5.46	**94.54**
24. Kentucky LaCrosse sandy loam	.395	.302	.093	23.55	**76.45**	.373	.330	.043	11.53	**88.47**	.293	.282	.011	3.75	**96.25**
25. Texas Houston black clay	.395	.265	.130	32.91	**67.09**	.373	.285	.088	23.59	**76.41**	.293	.262	.031	10.57	**89.43**

26. Texas Crawford clay	.395	.274	.121	30.63	**69.37**	.373	.294	.079	21.18	**78.82**	.293	.259	.034	11.60	**88.40**
27. Texas brownish black loam	.395	.271	.124	31.39	**68.61**	.373	.303	.070	18.77	**81.23**	.293	.272	.021	7.17	**92.83**
28. Texas fine sandy loam	.395	.302	.093	23.55	**76.45**	.373	.338	.035	9.38	**90.62**	.293	.273	.020	6.83	**93.17**
29. Texas Black sandy loam	.395	.330	.055	13.92	**86.08**	.373	.350	.023	6.17	**93.83**	.293	.280	.013	4.44	**95.56**
30. Texas Norfolk sandy loam	.395	.360	.035	8.86	**91.14**	.373	.375	−.002	−0.54	**100.54**	.293	.281	.012	4.09	**95.91**
31. Texas fine sand	.395	.330	.065	16.46	**83.54**	.373	.338	.035	9.38	**90.62**	.293	.290	.003	1.02	**98.98**
32. Texas fine sandy loam	.395	.345	.050	12.66	**87.34**	.373	.375	−.002	−0.54	**100.54**	.293	.310	−.017	−5.80	**105.80**
33. Washington heavy silt loam	.395	.291	.104	26.33	**73.67**	.373	.310	.063	16.89	**83.11**	.293	.272	.021	7.17	**92.83**
34. Washington silt loam	.395	.295	.100	25.32	**74.68**	.373	.303	.070	18.77	**81.23**	.293	.262	.031	10.58	**89.42**
35. Washington fine sandy loam	.395	.292	.103	26.08	**73.92**	.373	.328	.045	12.06	**87.94**	.293	.287	.006	2.05	**97.95**
36. Washington silt loam	.395	.297	.098	24.81	**75.19**	.373	.327	.046	12.33	**87.67**	.293	.287	.006	2.05	**97.95**
37. Washington silt loam	.395	.300	.095	24.05	**75.95**	.373	.313	.060	16.09	**83.91**	.293	.280	.013	4.44	**95.56**
38. Washington fine sand	.395	.300	.095	24.05	**75.95**	.373	.320	.053	14.21	**85.79**	.293	.285	.008	2.73	**97.27**
39. Washington silt loam	.395	.280	.115	29.11	**70.89**	.373	.319	.054	14.48	**85.52**	.293	.279	.014	4.78	**95.22**
40. Washington sand loam	.395	.290	.105	26.58	**73.42**	.373	.325	.048	12.87	**87.13**	.293	.290	.003	1.02	**98.98**
41. Florida Prairie sand	.395	.342	.053	13.42	**86.58**	.373	.352	.021	5.63	**94.37**	.293	.279	.014	4.78	**95.22**
42. Florida Prairie sand	.395	.343	.052	13.16	**86.84**	.373	.353	.020	5.36	**94.64**	.293	.272	.021	7.17	**92.28**
43. Florida Prairie sand	.395	.356	.039	9.87	**90.13**	.373	.373	0	0	**100.0**	.293	.289	.004	1.36	**98.64**
44. Wisconsin Superior clay	.395	.271	.124	31.39	**68.61**	.373	.303	.070	18.77	**81.23**	.293	.300	−.007	−2.39	**102.39**
45. Wisconsin Carrington silt loam	.395	.297	.098	24.81	**75.19**	.373	.320	.053	14.21	**86.79**	.293	.285	.008	2.43	**97.57**
46. Wisconsin Carrington silt loam	.395	.293	.102	25.82	**74.18**	.373	.320	.053	14.21	**85.79**	.293	.282	.011	3.75	**96.25**
47. Wisconsin Miami silt loam	.395	.297	.098	24.81	**75.19**	.373	.317	.056	15.01	**84.99**	.293	.261	.032	10.92	**89.08**
48. Wisconsin Miami silt loam	.395	.328	.067	16.96	**83.04**	.373	.331	.042	11.26	**88.74**	.293	.286	.007	2.39	**97.61**
49. Wisconsin Colby silt loam	.395	.287	.108	27.34	**72.66**	.373	.305	.068	18.23	**81.77**	.293	.262	.031	10.58	**89.42**
50. Wisconsin Plainfield fine sand	.395	.328	.067	16.96	**83.04**	.373	.356	.017	4.56	**95.41**	.293	.285	.008	2.43	**97.57**
51. Minnesota clay	.395	.283	.112	28.36	**71.64**	.373	.307	.066	17.69	**82.51**	.293	.280	.013	4.44	**95.56**
52. Minnesota sandy loam	.395	.298	.097	24.56	**75.44**	.373	.307	.066	17.69	**82.31**	.293	.268	.025	8.53	**91.47**
53. Minnesota sandy loam	.395	.258	.137	34.68	**65.32**	.373	.317	.056	15.01	**84.99**	.293	.253	.040	13.65	**86.35**
54. Minnesota sand	.395	.337	.058	14.68	**85.32**	.373	.357	.016	4.29	**95.71**	.293	.299	−.006	−2.05	**102.05**
55. California Chino silty clay loam	.395	.293	.102	25.82	**74.18**	.373	.300	.073	19.57	**80.43**	.293	.255	.038	12.97	**87.03**
56. California Kamona clay loam	.395	.291	.104	26.33	**73.67**	.373	.298	.075	20.11	**79.89**	.293	.300	−.007	−2.39	**102.39**
57. California Holland loam	.395	.272	.123	31.14	**68.86**	.373	.312	.061	16.35	**83.65**	.293	.283	.010	3.41	**96.59**
58. California Harford fine sandy loam	.395	.282	.113	28.61	**71.39**	.373	.321	.052	13.94	**86.06**	.293	.270	.023	7.85	**92.15**
59. California fine sandy loam	.395	.282	.113	28.61	**71.39**	.373	.328	.045	12.06	**87.94**	.293	.272	.021	7.17	**92.83**
60. California Oakley fine sandy loam	.395	.296	.099	25.06	**74.94**	.373	.331	.042	11.46	**88.54**	.293	.301	−.008	−2.73	**102.73**
61. Muck	.388	.280	.108	27.84	**72.16**	.360	.279	.081	22.50	**77.50**	.271	.239	.032	11.81	**88.19**
62. Peat	.388	.302	.086	22.16	**77.84**	.360	.301	.059	16.39	**83.61**	.271	.242	.029	10.70	**89.30**
63. Quartz sand	.395	.363	.032	8.10	**91.90**	.373	.370	.003	0.80	**99.20**	.283	.273	.020	6.83	**93.17**
64. Kaolin						.373	.373	0	0	**100.0**	.293	.287	.006	2.05	**97.95**
65. Light silt loam (burned)	.388	.378	.010	2.58	**97.42**	.360	.368	−.008	−2.22	**102.22**	.271	.269	.002	0.74	**99.26**
66. Heavy silt loam (burned)	.395	.339	.056	14.18	**85.82**	.373	.340	.033	8.85	**91.15**	.293	.269	.024	8.19	**91.81**
67. Light clay loam (burned)	.395	.362	.033	8.35	**91.65**	.373	.350	.023	6.17	**93.83**	.293	.270	.023	7.85	**92.15**

Table 12.—Continued.

Soils.	n/10 KNO_3					n/10 $(NH_4)_2SO_4$					n/10 K_2SO_4				
	Depression of Solution alone.	Depression of Solution with Soil.	Difference.	Percentage of change in Depression.	Percentage of Original Concentr. of Salt Solution Went to Concentrate Soil Solution.	Depression of Solution alone.	Depression of Solution with Soil.	Difference.	Percentage of change in Depression.	Percentage of Original Concentr. of Salt Solution Went to Concentrate Soil Solution.	Depression of Solution alone.	Depression of Solution with Soil.	Difference.	Percentage of change in Depression.	Percentage of Original Concentr. of Salt Solution Went to Concentrate Soil Solution.
	°C	°C	°C			°C	°C	°C			°C	°C	°C		
1. Heavy silt loam	.374	.285	.089	23.80	**76.20**	.243	.135	.108	44.44	**55.56**	.246	.121	.125	50.82	**49.18**
2. Heavy silt loam	.374	.267	.107	28.61	**71.39**	.239	.125	.114	47.70	**52.30**	.241	.125	.116	48.14	**51.86**
3. Heavy silt loam	.374	.265	.109	29.14	**70.86**	.239	.128	.111	46.44	**53.56**	.241	.100	.141	58.50	**41.50**
4. Heavy silt loam	.....	.....	.....	.....	.....	.239	.120	.119	49.79	**50.21**	.241	.112	.129	53.53	**46.47**
5. Light silt loam	.374	.302	.072	19.25	**80.75**	.239	.144	.095	39.75	**60.25**	.241	.131	.110	45.64	**54.36**
6. Heavy silt loam	.374	.257	.117	31.28	**68.72**	.239	.128	.111	46.45	**53.55**	.241	.124	.117	48.55	**51.45**
7. Light clay loam	.374	.266	.108	28.88	**71.12**	.239	.196	.043	17.99	**82.01**	.241	.178	.063	26.14	**73.86**
8. Heavy silt loam	.374	.298	.076	20.32	**79.68**	.239	.155	.084	35.15	**64.85**	.241	.133	.108	44.81	**55.19**
9. Light silt loam	.374	.272	.102	27.27	**72.73**	.239	.121	.118	49.38	**50.62**	.241	.120	.121	50.21	**49.79**
10. Heavy silt loam	.374	.303	.071	18.98	**81.02**	.243	.152	.091	37.45	**62.55**	.246	.181	.065	26.42	**73.58**
11. Very light silt loam	.374	.279	.095	25.40	**74.60**	.239	.120	.119	49.79	**50.21**	.241	.098	.143	59.34	**40.66**
12. Heavy sandy loam	.374	.278	.096	25.67	**74.33**	.239	.131	.108	45.19	**54.81**	.241	.110	.131	54.36	**45.64**
13. Fine sandy loam (black)	.....	.....	.....	.....	.....	.239	.170	.069	28.87	**71.13**	.241	.155	.086	35.68	**64.32**
14. Sand (gray)	.374	.345	.029	7.75	**92.25**	.239	.236	.003	1.26	**98.74**	.241	.209	.032	13.28	**86.72**
15. Light sandy loam	.374	.328	.046	12.30	**87.70**	.239	.188	.051	21.34	**78.66**	.241	.170	.071	29.46	**70.54**
16. Penn. silt loam	.370	.315	.055	14.86	**85.14**	.253	.141	.112	44.27	**55.73**	.251	.130	.121	48.21	**51.79**
17. Penn. silt loam	.370	.286	.084	22.71	**77.29**	.253	.146	.107	42.29	**57.71**	.251	.137	.114	45.42	**54.58**
18. Penn. silt loam	.370	.277	.093	25.14	**74.86**	.253	.139	.114	45.06	**54.94**	.251	.127	.124	49.40	**50.60**
19. Penn. silt loam	.370	.281	.089	24.05	**75.95**	.253	.154	.099	39.13	**60.87**	.251	.139	.112	44.62	**55.38**
20. Kentucky Carrington clay loam	.370	.268	.102	27.57	**72.43**	.253	.156	.096	37.94	**62.06**	.251	.133	.118	47.02	**52.98**
21. Kentucky Marshall silt loam	.370	.278	.092	24.87	**75.13**	.253	.125	.128	50.60	**49.40**	.251	.120	.131	52.50	**47.80**
22. Kentucky Miami silt loam	.370	.283	.087	23.51	**76.49**	.253	.142	.111	43.88	**56.12**	.251	.132	.119	47.41	**52.59**
23. Kentucky Carrington loam	.370	.260	.110	29.73	**70.27**	.253	.127	.126	49.80	**50.20**	.251	.112	.139	55.38	**44.62**
24. Kentucky LaCrosse sandy loam	.370	.291	.079	21.35	**78.65**	.253	.153	.100	39.53	**60.47**	.251	.135	.116	46.22	**53.78**
25. Texas Houston black clay	.370	.245	.125	33.79	**66.21**	.253	.093	.160	63.24	**36.76**	.251	.092	.159	63.35	**36.65**

26. Texas Crawford clay	.370	.244	.126	34.05	65.95	.253	.114	.139	54.94	45.06	.251	.104	.147	58.57	41.43
27. Texas Brownish black loam	.370	.260	.110	29.73	70.27	.253	.112	.141	55.73	44.27	.251	.105	.146	58.17	41.83
28. Texas fine sandy loam	.370	.287	.083	22.43	77.57	.253	.151	.102	40.32	59.68	.251	.150	.101	40.24	59.76
29. Texas Black sandy loam	.370	.312	.058	15.68	84.32	.253	.195	.058	22.93	77.07	.251	.190	.061	24.30	75.70
30. Texas Norfolk sandy loam	.370	.343	.037	10.00	90.00	.253	.221	.032	12.65	87.35	.251	.215	.036	14.34	85.66
31. Texas fine sand	.370	.310	.060	16.22	83.78	.253	.190	.063	24.90	75.10	.251	.187	.064	25.50	74.50
32. Texas fine sandy loam	.370	.337	.033	8.92	91.08	.253	.223	.030	11.86	88.14	.251	.212	.039	15.54	84.46
33. Washington heavy silt loam	.370	.271	.099	26.76	73.24	.253	.131	.122	48.22	51.78	.251	.130	.121	48.21	51.79
34. Washington silt loam	.370	.272	.098	26.49	73.51	.253	.122	.131	51.78	48.22	.251	.124	.127	50.60	49.40
35. Washington fine sandy loam	.370	.288	.082	22.16	77.84	.253	.140	.113	44.67	55.33	.251	.137	.114	45.42	54.58
36. Washington silt loam	.370	.270	.100	27.03	72.97	.253	.127	.126	49.80	50.20	.251	.117	.134	53.39	46.61
37. Washington silt loam	.370	.258	.112	30.27	69.73	.253	.130	.123	48.62	51.38	.251	.122	.129	51.40	48.60
38. Washington fine sand	.370	.283	.087	23.51	76.49	.253	.148	.105	41.51	58.49	.251	.143	.108	43.03	56.97
39. Washington silt loam	.370	.270	.100	27.03	72.97	.253	.109	.144	56.92	43.08	.251	.106	.145	57.77	42.23
40. Washington sand loam	.370	.292	.078	21.08	78.92	.253	.115	.138	54.55	45.45	.251	.109	.142	56.57	43.43
41. Florida Prairie sand	.370	.317	.053	14.32	85.68	.253	.202	.051	20.16	79.84	.251	.205	.046	18.33	81.67
42. Florida Prairie sand	.370	.331	.039	10.54	89.46	.253	.230	.023	9.09	90.91	.251	.203	.048	19.12	80.88
43. Florida Prairie sand	.370	.343	.027	7.30	92.60	.253	.228	.025	9.88	90.12	.251	.209	.042	16.73	83.27
44. Wisconsin Superior clay	.370	.278	.092	24.87	75.13	.253	.111	.142	56.13	43.87	.251	.103	.148	58.96	41.04
45. Wisconsin Carrington silt loam	.370	.278	.092	24.87	75.13	.253	.138	.115	45.46	54.54	.251	.127	.124	49.40	50.60
46. Wisconsin Carrington silt loam	.370	.275	.095	25.68	74.32	.253	.138	.115	45.46	54.54	.251	.125	.126	50.20	49.80
47. Wisconsin Miami silt loam	.370	.270	.100	27.03	72.97	.253	.152	.101	39.92	60.08	.251	.142	.109	43.43	56.57
48. Wisconsin Miami silt loam	.370	.292	.078	21.08	78.92	.253	.170	.083	32.81	67.19	.251	.158	.093	37.05	62.95
49. Wisconsin Colby silt loam	.370	.253	.117	31.62	68.38	.253	.130	.123	48.62	51.38	.251	.113	.138	54.98	45.02
50. Wisconsin Plainfield fine sand	.370	.325	.045	12.16	87.84	.253	.177	.076	30.04	69.96	.251	.170	.081	32.27	67.73
51. Minnesota clay	.370	.272	.098	26.49	73.51	.253	.110	.143	56.52	43.48	.251	.123	.128	51.00	49.00
52. Minnesota sandy loam	.370	.267	.103	27.84	72.16	.253	.148	.105	41.51	58.49	.251	.151	.100	39.84	60.16
53. Minnesota sandy loam	.370	.250	.120	32.43	67.57	.253	.090	.163	64.43	35.57	.251	.073	.178	70.92	29.08
54. Minnesota sand	.370	.312	.058	15.68	84.32	.253	.185	.068	26.88	73.12	.251	.177	.074	29.48	70.52
55. California Chino silty clay loam	.370	.270	.100	27.03	72.97	.253	.128	.125	49.41	50.59	.251	.102	.149	59.36	40.64
56. California Ramona clay loam	.370	.260	.110	29.65	70.35	.253	.105	.148	58.50	41.50	.251	.090	.161	64.14	35.86
57. California Holland loam	.370	.263	.107	28.92	31.08	.253	.132	.121	47.83	52.17	.251	.122	.129	51.40	48.60
58. California Harford fine sandy loam	.370	.280	.090	24.32	75.68	.253	.148	.115	45.46	54.54	.251	.138	.113	45.02	54.98
59. California Golo fine sandy loam	.370	.275	.095	25.67	74.33	.253	.132	.121	47.83	52.17	.251	.125	.126	50.20	49.80
60. California Oakley fine sandy loam	.370	.289	.081	21.89	78.11	.253	.159	.094	37.16	62.84	.251	.134	.117	46.62	53.38
61. Muck	.370	.251	.119	32.16	67.84	.253	.129	.124	49.02	50.98	.251	.116	.135	53.79	46.21
62. Peat	.370	.264	.106	28.65	71.35	.253	.162	.091	35.97	64.03	.251	.154	.097	38.65	61.35
63. Quartz sand	.370	.370	0	0	100.0	.253	.250	.003	1.18	98.82	.251	.232	.019	7.57	92.43
64. Kaolin	.370	.370	0	0	100 0	......	......	......	......	......	.251	.240	.011	4.38	95.65
65. Light silt loam (burned)	.370	.365	.005	1.35	98.65	.253	.238	.015	5.93	94.07	.251	.238	.013	5.18	94.82
66. Heavy silt loam (burned)	.370	.339	.031	8.38	91.62	.253	.221	.032	12.65	87.35	.251	.219	.032	12.75	87.25
67. Light clay loam (burned)	.370	.345	.025	6.76	93.24	.253	.230	.023	9.09	90.91	.251	.240	.011	4.38	95.62

Table 12.—Concluded.

Soils.	n/10 $MgSO_4$ Depression of Solution alone.	n/10 $MgSO_4$ Depression of Solution with Soil.	n/10 $MgSO_4$ Difference.	n/10 $MgSO_4$ Percentage of change in Depression.	n/10 $MgSO_4$ Percentage of Original Concentr. of Salt Solution Went to Concentrate Soil Solution.	n/10 $NaC_2H_3O_2$ Depression of Solution alone.	n/10 $NaC_2H_3O_2$ Depression of Solution with Soil.	n/10 $NaC_2H_3O_2$ Difference.	n/10 $NaC_2H_3O_2$ Percentage of change in Depression.	n/10 $NaC_2H_3O_2$ Percentage of Original Concentr. of Salt Solution Went to Concentrate Soil Solution.	n/10 $CaH_4(PO_4)_2$ Depression of Solution alone.	n/10 $CaH_4(PO_4)_2$ Depression of Solution with Soil.	n/10 $CaH_4(PO_4)_2$ Difference.	n/10 $CaH_4(PO_4)_2$ Percentage of change in Depression.	n/10 $CaH_4(PO_4)_2$ Percentage of Original Concentr. of Salt Solution Went to Concentrate Soil Solution.	n/10 K_2HPO_4 Depression of Solution alone.	n/10 K_2HPO_4 Depression of Solution with Soil.	n/10 K_2HPO_4 Difference.	n/10 K_2HPO_4 Percentage of change in Depression.	n/10 K_2HPO_4 Percentage of Original Concentr. of Salt Solution Went to Concentrate Soil Solution.
	°C	°C	°C			°C	°C	°C			°C	°C	°C			°C	°C	°C		
1. Heavy silt loam	.....	.....	.....	.....	.....	.396	.333	.063	15.91	**84.09**	.073	.003	.070	95.88	**4.12**	.154	.014	.140	90.91	**9.09**
2. Heavy silt loam	.....	.....	.....	.....	.....	.396	.310	.086	21.72	**78.28**	.085	.005	.080	94.12	**5.88**	.154	.002	.152	98.70	**1.30**
3. Heavy silt loam	.....	.....	.....	.....	.....	.396	.300	.096	24.24	**75.76**	.076	.003	.073	96.06	**3.94**	.159	.014	.145	91.20	**8.80**
4. Heavy silt loam	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.076	.010	.066	86.84	**13.16**	.159	.013	.146	91.82	**8.18**
5. Light silt loam	.....	.....	.....	.....	.....	.396	.349	.047	11.87	**88.13**	.085	.008	.077	90.59	**9.41**	.154	.020	.134	87.01	**12.99**
6. Heavy silt loam	.....	.....	.....	.....	.....	.396	.324	.072	18.18	**81.82**	.076	0	.076	100.0	**0**	.159	.003	.156	98.12	**1.88**
7. Light clay loam	.....	.....	.....	.....	.....	.396	.330	.066	16.67	**83.33**	.076	.003	.073	96.05	**3.95**	.159	.012	.147	92.46	**7.54**
8. Heavy silt loam	.....	.....	.....	.....	.....	.396	.343	.053	13.38	**86.62**	.085	.005	.080	94.12	**5.88**	.154	.020	.134	87.01	**12.99**
9. Light silt loam	.....	.....	.....	.....	.....	.396	.337	.059	14.90	**85.10**	.076	.011	.065	85.53	**14.47**	.159	.018	.141	88.68	**11.32**
10. Heavy silt loam	.....	.....	.....	.....	.....	.396	.341	.055	13.89	**86.11**	.085	.003	.082	96.48	**3.52**	.154	0	.154	100.0	**0**
11. Very light silt loam	.....	.....	.....	.....	.....	.396	.364	.032	8.08	**91.92**	.085	.007	.078	91.77	**8.23**	.154	0	.154	100.0	**0**
12. Heavy sandy loam	.....	.....	.....	.....	.....	.396	.343	.053	13.38	**86.62**	.085	−.001	.086	101.20	**−1.20**	.159	0	.159	100.0	**0**
13. Fine sandy loam	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.085	0	.085	100.0	**0**	.154	.020	.134	87.01	**12.99**
14. Sand (gray)	.....	.....	.....	.....	.....	.396	.385	.011	2.78	**97.22**	.085	.034	.051	60.00	**40.00**	.154	.079	.075	48.70	**51.30**
15. Light sandy loam	.....	.....	.....	.....	.....	.396	.385	.011	2.78	**97.22**	.076	.002	.074	97.37	**2.63**	.159	.028	.131	82.39	**17.61**
16. Penn. silt loam N 32	.085	.055	.030	35.29	**64.71**	.....	.....	.....	.....	.....	.080	.008	.072	90.00	**10.00**	.165	.015	.150	90.90	**9.10**
17. Penn. silt loam N 26	.085	.065	.020	23.53	**76.47**	.395	.306	.089	22.53	**77.47**	.080	.005	.075	93.74	**6.26**	.165	.012	.153	92.72	**7.28**
18. Penn. silt loam N 21	.085	.062	.023	27.06	**72.94**	.395	.293	.102	25.82	**74.18**	.080	.009	.071	88.75	**11.25**	.165	.012	.153	92.72	**7.28**
19. Penn. silt loam N 18	.085	.074	.011	12.94	**87.06**	.395	.319	.076	19.24	**80.76**	.....	.....	.....	.....	.....	.165	.019	.146	88.48	**11.52**
20. Kentucky Carrington clay loam	.085	.078	.007	8.23	**91.77**	.395	.333	.062	15.70	**84.30**	.080	.008	.072	90.00	**10.00**	.165	.021	.144	87.27	**12.73**
21. Kentucky Marshall silt loam	.085	.068	.017	20.00	**80.00**	.395	.321	.074	18.74	**81.26**	.080	.010	.070	87.50	**12.50**	.165	.013	.152	92.12	**7.88**
22. Kentucky Miami silt loam	.085	.073	.012	14.12	**85.88**	.395	.294	.091	23.04	**76.96**	.080	.012	.068	85.00	**15.00**	.165	.027	.138	83.63	**16.37**
23. Kentucky Carrington loam	.085	.072	.013	15.29	**84.71**	.395	.295	.100	25.32	**74.68**	.080	.008	.072	90.00	**10.00**	.165	.017	.148	89.70	**10.30**
24. Kentucky LaCrosse sandy loam	.085	.078	.007	8.24	**91.76**	.395	.341	.054	13.67	**86.33**	.080	.013	.067	83.74	**16.26**	.165	.030	.135	81.82	**18.18**
25. Texas Houston black clay	.085	.055	.030	35.29	**64.71**	.395	.295	.100	25.32	**74.68**	.080	.002	.082	102.50	**−2.50**	.165	−.004	.169	102.24	**−2.24**

26. Texas Crawford clay	.085	.071	.014	16.47	**83.53**	.395	.264	.131	33.17	**66.83**	.080	0	.080	100.0	**0**	.165	.004	.161	97.57	**2.43**
27. Texas Brownish black loam	.085	.063	.022	25.88	**74.12**	.395	.257	.138	35.19	**64.81**	.080	.003	.077	96.25	**3.75**	.165	.003	.162	98.18	**1.82**
28. Texas fine sandy loam	.085	.065	.020	23.53	**76.47**	.395	.340	.055	13.92	**86.08**	.080	.012	.068	85.00	**15.00**	.165	.020	.145	87.87	**12.13**
29. Texas Black sandy loam	.085	.081	.004	4.71	**95.29**	.395	.360	.035	8.86	**91.14**	.080	.031	.049	61.25	**38.75**	.165	.065	.100	60.60	**39.40**
30. Texas Norfolk sandy loam	.085	.075	.010	11.76	**88.24**	.395	.378	.017	4.30	**95.70**	.080	.030	.050	62.50	**37.50**	.165	.072	.093	56.36	**43.64**
31. Texas fine sand	.085	.071	.014	16.47	**83.53**	.395	.380	.015	3.80	**96.20**	.080	.002	.07[illegible]	97.50	**2.50**	.165	.030	.135	81.81	**18.19**
32. Texas fine sandy loam	.085	.082	.003	3.53	**96.47**	.395	.390	.005	1.27	**98.73**	.080	.022	.058	72.50	**27.50**	.165	.063	.102	61.82	**38.18**
33. Washington heavy silt loam	.085	.072	.013	15.29	**84.71**	.395	.315	.080	20.25	**79.75**	.080	.003	.077	96.25	**3.75**	.165	.010	.155	93.94	**6.06**
34. Washington silt loam	.085	.067	.018	21.18	**78.82**	.395	.315	.080	20.25	**79.75**	.080	.015	.065	81.25	**18.75**	.165	.030	.135	81.82	**18.18**
35. Washington fine sandy loam	.085	.080	.005	5.88	**94.12**	.395	.272	.123	31.14	**68.86**	.080	.017	.063	78.75	**21.25**	.165	.032	.133	80.61	**19.39**
36. Washington silt loam	.085	.069	.016	18.82	**81.18**	.395	.262	.133	33.67	**66.33**	.080	.012	.068	85.00	**15.00**	.165	.022	.143	86.67	**13.33**
37. Washington silt loam	.085	.068	.017	20.00	**80.00**	.395	.250	.145	36.71	**63.29**	.080	.010	.070	87.50	**12.50**	.165	.015	.150	90.91	**9.09**
38. Washington fine sand	.085	.071	.014	16.47	**83.53**	.395	.320	.075	18.99	**81.01**	.080	.016	.064	80.00	**20.00**	.165	.028	.137	83.02	**16.98**
39. Washington silt loam	.085	.064	.021	24.70	**75.30**	.395	.319	.076	19.24	**80.76**	.080	.009	.071	88.75	**11.25**	.165	.014	.151	91.52	**8.48**
40. Washington sandy loam	.085	.062	.023	27.06	**72.94**	.395	.342	.053	13.42	**86.58**	.080	.019	.061	76.25	**23.75**	.165	.043	.122	73.94	**26.06**
41. Florida Prairie sand	.085	.084	.001	1.17	**98.83**	.395	.324	.071	17.98	**82.02**	.080	.027	.053	66.25	**33.75**	.165	.028	.137	83.02	**16.98**
42. Florida Prairie sand	.085	.071	.014	16.47	**83.53**	.395	.347	.048	12.15	**87.85**	.080	.001	.079	98.75	**1.25**	.165	.042	.123	74.54	**25.46**
43. Florida Prairie sand	.085	.080	.005	5.88	**94.12**	.395	.368	.027	6.84	**93.16**	.080	.008	.072	90.00	**10.00**	.165	.023	.142	86.06	**13.94**
44. Wisconsin Superior clay	.085	.068	.017	20.00	**80.00**	.395	.295	.100	25.32	**74.68**	.080	.010	.070	87.50	**12.50**	.165	.005	.160	96.97	**3.03**
45. Wisconsin Carrington silt loam	.085	.068	.017	20.00	**80.00**	.395	.299	.096	24.30	**75.70**	.080	.007	.073	91.25	**8.75**	.165	.017	.148	89.70	**10.30**
46. Wisconsin Carrington silt loam	.085	.070	.015	17.65	**82.35**	.395	.293	.102	25.82	**74.18**	.080	.001	.079	98.75	**1.25**	.165	0.0	.165	100.0	**0**
47. Wisconsin Miami silt loam	.085	.072	.013	15.29	**84.71**	.395	.237	.158	40.00	**80.00**	.080	0	.080	100.0	**0**	.165	.010	.155	93.94	**6.06**
48. Wisconsin Miami silt loam	.085	.079	.006	7.06	**92.94**	.395	.309	.086	21.77	**78.23**	.080	.008	.072	90.00	**10.00**	.165	.018	.147	89.09	**11.91**
49. Wisconsin Colby silt loam	.085	.062	.023	27.06	**72.94**	.395	.275	.120	30.38	**69.62**	.080	.001	.079	98.75	**1.25**	.165	.010	.155	93.94	**6.06**
50. Wisconsin Plainfield fine sand	.085	.070	.015	17.65	**82.35**	.395	.328	.067	16.96	**83.04**	.080	.006	.074	92.50	**7.50**	.165	.018	.147	89.08	**10.92**
51. Minnesota clay	.085	.060	.025	29.41	**70.59**	.395	.282	.113	28.61	**71.39**	.080	.005	.075	93.74	**6.26**	.165	.012	.153	92.72	**7.28**
52. Minnesota sandy loam	.085	.089	−.004	−4.71	**104.71**	.395	.347	.048	12.15	**87.85**	.080	.007	.073	91.25	**8.75**	.165	.014	.151	91.51	**8.49**
53. Minnesota sandy loam	.085	.038	.047	55.30	**44.70**	.395	.211	.184	46.58	**53.42**	.080	.005	.075	93.75	**6.25**	.165	.007	.158	95.76	**4.24**
54. Minnesota sand	.085	.085	0	0	**100.0**	.395	.327	.068	17.22	**82.78**	.080	.007	.073	91.25	**8.75**	.165	.027	.138	83.63	**12.37**
55. California Chino silty clay loam	.085	.045	.040	47.06	**52.94**	.395	.260	.135	34.18	**65.82**	.080	0	.080	100.0	**0**	.165	.035	.130	78.78	**21.22**
56. California Ramona clay loam	.085	.065	.020	23.53	**76.47**	.395	.320	.075	18.99	**81.01**	.080	.010	.070	87.50	**12.50**	.165	.017	.148	89.70	**10.30**
57. California Holland loam	.085	.063	.022	25.88	**74.12**	.395	.312	.083	21.01	**78.99**	.080	.012	.068	85.00	**15.00**	.165	.020	.145	87.87	**12.13**
58. California Harford fine sandy loam	.085	.070	.015	17.65	**82.35**	.395	.305	.090	22.79	**77.21**	.080	0	.080	100.0	**0**	.165	.020	.145	87.87	**12.13**
59. California Golo fine sandy loam	.085	.072	.013	15.29	**84.71**	.395	.222	.173	43.80	**56.20**	.080	.030	.050	62.50	**37.50**	.165	.050	.115	69.70	**30.30**
60. California Oakley fine sandy loam	.085	.081	.004	4.71	**95.29**	.395	.309	.086	21.77	**78.23**	.083	.019	.061	76.25	**23.75**	.165	.024	.141	85.45	**14.55**
61. Muck	.085	.062	.023	27.06	**72.94**	.395	.269	.126	31.90	**68.10**	.080	.001	.079	98.75	**1.25**	.165	.001	.164	99.39	**0.61**
62. Peat	.085	.062	.023	27.06	**72.94**	.395	.279	.116	29.37	**70.63**	.080	.002	.078	97.50	**2.50**	.165	.019	.146	88.48	**11.52**
63. Quartz sand	.085	.085	0	0	**100.0**	.395	.385	.010	2.53	**97.47**	.080	.075	.005	6.25	**93.75**	.165	.153	.012	7.27	**92.73**
64. Kaolin	.085	.035	0	0	**100.0**	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
65. Light silt loam (burned)	.085	.091	−.006	−7.06	**107.06**	.395	.388	.007	1.77	**98.23**	.080	.018	.062	77.50	**22.50**	.165	.118	.047	28.49	**71.51**
66. Heavy silt loam (burned)	.085	.090	−.005	−5.88	**105.88**	.395	.369	.026	6.58	**93.42**	.080	.001	.079	98.75	**1.25**	.165	.051	.114	69.09	**30.91**
67. Light clay loam (burned)	.085	.088	−.003	−3.53	**103.53**	.395	.368	.027	6.84	**93.16**	.080	.022	.058	72.50	**27.50**	.165	.102	.063	38.18	**61.82**

Before entering into the discussion of the foregoing data an explanation as to their form of presentation is necessary. The first column to the left of each salt solution contains the lowering of the freezing point of the solution alone; the second column contains the freezing-point depression of the soil treated with the solution, and this freezing-point depression is entirely due to the solution applied, as the amount of depression due to the soil itself at that moisture content has been subtracted. The third column shows the difference in the depression of the solution before and after it was added to the soil. The fourth column contains the percentage of change in the depression that the salt solution suffered in the soil; and, the fifth column shows what percentage of the original concentration of the salt solution went to increase the concentration of the soil solution.

With these explanations, the above data showing the influence of the application of soluble salts upon the concentration of the soil solution in the soil may be considered. An examination of the figures in the fifth column of the various salt solutions reveals many interesting and important facts. Starting first with KCl solution it will be seen that from about 65 to 98% of the original concentration of this salt solution went to concentrate the soil solution. The concentration of the soil solution increased to the greatest degree in quartz sand, kaolin, sand, and burned soils, and least in clays and clay loams.

Considering next $NaNO_3$, it will be observed that on an average much larger percentage of the concentration of this salt solution went to augment the strength of the soil solution of the various soils. The degree of concentration varies from about 76 to 100%, but in the majority of cases it lies between 85 and 90%. The magnitude of concentration is greatest in quartz sand, koalin, sand, and burned soils, and smallest in clay loams, and clays.

The $CaNO_3$ solution increased the concentration of the soil solution of nearly all the diverse classes of soils, including the clay loams, and clays, about 100%. This is indeed exceedingly interesting and of great importance.

The KNO_3 solution augmented the strength of the soil solution of the various soils considerably less than did $Ca(NO_3)_2$ and $NaNO_3$ but about the same as the KCl. It will be observed that the agreement in the results between these two salt solutions is remarkably close.

The $(NH_4)_2SO_4$ solution increased the concentration of the soil solution of some soils very greatly while in others only a very small amount. Thus, in quartz sand, kaolin, sand, burned soils, the greatest part if not all of the original strength went to augment the concentration of the solution of these substances, but in the clay loams, clays, etc., only a small portion of the original strength of the solution was used for the same purpose, amounting in some cases to only 35%.

The K_2SO_4 solution increased the concentration of the solution of the various soils, with the exception of quartz sand, kaolin, sand, and burned soils, on an average still less than did the $(NH_4)_2SO_4$ solution. An examination of the data shows that in some of the clay loams, clays. only about 35% of the original concentration of the salt solution was imparted to the concentration of the soil solution. For the majority of the soils the value lies close to 50%.

The increase in concentration of the soil solution produced by the

$MgSO_4$ solution varies from about 55% in the case of some clays to about 100% in the case of the artificial substances. On the whole, however, the percentage of the original concentration that was imparted to the solution of the various agricultural soils is quite high.

The $NaC_2H_3O_2$ solution increased the strength of the solution of the different soils to a high degree. In the case of the more artificial substances, quartz sand, kaolin, etc., the increase amounts to about 100% and in the agricultural soils it lies between 70 and 90%, with few exceptions.

Of all the salts used the phosphates increased the concentration of the soil solution of the agricultural soils to the last degree. Indeed it will be seen that, with the exception of the artificial substances, the strength of the soil solution of all the agricultural soils is increased in most cases to only about 10%. Hence, the acid phosphate salts produced entirely different results from the neutral salts.

This part of the main investigation, therefore confirms the previous results and conclusions, and goes to show that the different compounds employed have an entirely different effect upon the concentration of the solution of the various soils. In the case of the neutral salts the solution of the agricultural soils was increased from 35 to 100% of their added strength, while in the case of the acid phosphate salts only a very small portion if any of their concentration was added to the soil solution, amounting in the majority of cases to only 10%. All the salts including the phosphates, behaved the same in regard to the artificial substances, the quartz sand, kaolin, burned soils, etc., as they all increased the concentration of their solution to about the same degree, 100%. The neutral salt solutions did not behave uniformly in the different types of soils; some of the salts produced the greatest increase in concentration in the sands and the smallest in the clays, while other salts caused about the same degree of concentration in all the distinct types of soil.

The results obtained with the burned soils are of great interest and need special emphasis. These soils are the same as soils No. 1, 2, 3, and 4 in Table 12. They were burned to red heat in a muffle furnace. An examination of the results obtained from these soils shows that after burning they acted almost like quartz sand as the concentration of their solution was increased to almost 100% by all the salt solutions except the acid phosphates, while before burning such was not the case.

The question now is, how is the increase in concentration of the soil solution by the soluble salts brought about; and, what is the composition of the resulting solution? Before attempting to answer this question one more phase of the investigation should be considered.

EFFECT OF THE APPLICATION OF ACIDS UPON THE CONCENTRATION OF THE SOIL SOLUTION IN THE SOIL.

In conjunction with the foregoing studies just considered the effect of application of acids upon the concentration of the solution in the soil was also studied. The procedure of experimentation was the same as above. The acids employed consisted of HCl, HNO_3, H_2SO_4, $C_2H_2O_4$, $C_5H_5O_7$, and $HC_2H_3O_2$ in n/10 strength. There were only 13 soils used. The results obtained are shown in Table 13.

Table 13. Effect of Application of Acid Upon the Concentration of the Soil Solution.

Soils.	n/10 HCl.					n/10 HNO3.					n/10 H_2SO_4.				
	Depression of Solution alone	Depression of Solution with Soil.	Difference.	Percentage of change in Depression.	Percentage of Original Concentr. of Acid Solution Went to Concentrate Soil Solution.	Depression of Solution alone.	Depression of Solution with Soil.	Difference.	Percentage of change in Depression.	Percentage of Original Concentr. of Acid Solution Went to Concentrate Soil Solution.	Depression of Solution alone.	Depression of Solution with Soil.	Difference.	Percentage of change in Depression	Percentage of Original Concentr. of Acid Solution Went to Concentrate Soil Solution.
	°C	°C	°C			°C	°C	°C			°C	°C	°C		
1. Heavy silt loam	.382	.268	.114	29.84	70.16	.401	.283	.118	29.43	70.57	.255	.101	.154	60.40	39.60
2. Heavy silt loam	.382	.277	.105	27.49	72.51	.401	.277	.124	30.92	69.08	.255	.078	.177	69.42	30.58
3. Light clay loam	.382	.275	.107	28.01	71.99	.401	.270	.131	32.67	67.33	.255	.083	.172	67.45	32.55
4. Heavy silt loam	.382	.299	.083	21.73	78.27	.401	.282	.119	29.67	70.33	.255	.089	.166	65.10	34.90
5. Heavy silt loam	.382	.269	.113	29.58	70.42	.401	.270	.131	32.67	67.33	.255	.088	.167	65.50	34.50
6. Very light silt loam	.382	.275	.107	28.01	71.99	.401	.282	.119	29.68	70.32	.255	.118	.137	53.73	46.27
7. Heavy sandy loam	.382	.265	.117	30.63	69.37	.401	.261	.140	34.91	65.09	.255	.078	.177	69.42	30.58
8. Fine sandy loam	.382	.285	.097	25.39	64.61	.401	.275	.126	31.42	68.58	.255	.140	.115	45.10	54.90
9. Sand	.382	.272	.110	28.80	71.20	.401	.282	.119	29.68	70.32	.255	.133	.122	47.85	52.15
10. Light sandy loam	.382	.278	.104	27.23	72.77	.401	.280	.121	30.17	69.83	.255	.118	.137	53.73	46.27
11. Heavy silt loam (burned)	.382	.271	.111	29.06	70.94	.401	.282	.119	29.68	70.32	.255	.097	.158	61.96	38.04
12. Quartz	.382	.297	.085	22.25	77.75	.401	.362	.039	9.73	90.27	.255	.212	.043	16.86	83.14
13. Kaolin	.382	.282	.100	26.18	73.82	.401	.308	.093	23.19	76.81	.255	.170	.085	33.33	66.67

Table 13.—Concluded.

Soils.	n/10 $C_2H_2O_4$.					n/10 $C_6H_8O_7$.					n/10 $HC_2H_3O_2$.				
	Depression of Solution alone.	Depression of Solution with Soil.	Difference.	Percentage of change in Depression.	Percentage of Original Concentr. of Salt Solution Went to Concentrate Soil Solution	Depression of Solution alone.	Depression of Solution with Soil.	Difference.	Percentage of change in Depression.	Percentage of Original Concentr. of Salt Solution Went to Concentrate Soil Solution.	Depression of Solution alone.	Depression of Solution with Soil.	Difference.	Percentage of change in Depression.	Percentage of Original Concentr. of Salt Solution Went to Concentrate Soil Solution.
	°C	°C	°C			°C	°C	°C			°C	°C	°C		
1. Heavy silt loam	.306	.023	.283	92.48	**7.52**	.226	.119	.107	47.35	**52.65**	.188	.199	—.011	—5.85	**105.85**
2. Heavy silt loam	.306	.002	.304	99.34	**0.66**	.226	.105	.121	53.54	**46.46**	.188	.207	—.019	-10.10	**110.10**
3. Light clay loam	.306	.020	.286	93.46	**6.54**	.226	.142	.084	37.17	**62.83**	.188	.215	—.027	-14.36	**114.30**
4. Heavy silt loam	.306	.036	.270	88.23	**11.77**	.226	.144	.082	36.29	**63.71**	.188	.210	—.022	11.70	**111.70**
5. Heavy silt loam	.306	.028	.288	94.12	**5.88**	.226	.125	.101	44.69	**55.31**	.188	.203	—.015	—8.00	**108.00**
6. Very light silt loam	.306	.010	.296	96.73	**3.27**	.226	.111	.115	50.89	**49.11**	.188	.238	—.050	-26.59	**126.59**
7. Heavy sandy loam	.306	.002	.304	99.35	**0.65**	.226	.107	.119	52.65	**47.35**	.188	.210	—.022	-11.70	**111.70**
8. Fine sandy loam	.306	.016	.290	94.77	**5.23**	.226	.120	.106	46.90	**53.10**	.188	.245	—.057	-30.32	**130.32**
9. Sand	.306	.113	.193	63.07	**36.93**	.226	.197	.029	12.83	**87.17**	.188	.212	—.024	-12.77	**112.77**
10. Light sandy loam	.306	.011	.295	96.40	**3.60**	.226	.135	.091	40.27	**59.73**	.188	.220	—.032	-17.02	**117.02**
11. Heavy silt loam (burned)	.306	.050	.256	83.65	**16.35**	.226	.191	.035	15.49	**84.51**	.188	.242	—.054	-28.72	**128.72**
12. Quartz	.306	.282	.024	7.84	**92.16**	.226	.242	—.016	—7.08	**107.08**	.188	.197	—.009	—4.79	**104.79**
13. Kaolin	.306	.187	.119	38.89	**61.11**	.226	.208	.018	7.96	**92.04**	.188	.220	—.032	-17.02	**117.02**

The above data reveal many facts of high interest and great fundamental importance. They show (1) that the HCl and HNO_3 increased the concentration of the soil solution to about the same degree in all soils except in the quartz sand, and the magnitude lies between 60 and 70% for the majority of the agricultural soils; (2) The H_2SO_4 increased the concentration of the soil solution in the majority of the agricultural soils only about half as much as did the HCl and HNO_3. (3) The $C_2H_2O_4$ caused very little if any increases in concentration in the agricultural soils, except in the artificial substances. (4) The $C_6H_8O_7$ caused an increase of over 50% in the agricultural soils and nearly 100% in the artificial substances. (5) The $HC_2H_3O_2$ produced an augmentation in the strength of the soils solution of all the soils employed of over 100%. In some cases the magnitude of increase is as great as 130%. These last results are certainly remarkable for they signify that the concentration of the soil solution is augmented above the total concentration of the acid added.

The question raised above—how is the increase in concentration of the soil solution by the application of soluble salts brought about, and what is the composition of the resulting solution—may be raised also in the case of the acids just considered.

To obtain an answer to the above question it is necessary to resort to other means for the lowering of the freezing point unfortunately indicates only concentration and tells nothing of the reactions that might take place between the soil and the salt solutions or acids, or of the composition of the resulting solution.

In the study of absorption or fixation of salts by soils one of two methods is generally employed: (1) either shake a certain amount of soil with an excess amount of solution and analyze the supernatant liquid, or (2) pass through a column of soil a salt solution and analyze the percolate. These studies have shown that in the case of neutral salts the amount of the base of the salt solution added is diminished and an equivalent or nearly equivalent quantity of other bases is dissolved into the solution. Thus, if a soil is treated with a solution of KCl the amount of K in the resulting solution is diminished but is replaced almost by an equivalent quantity of other bases such as Ca, Mg, etc., while the amount of Cl remains practically unchanged.

In explanation of this phenomenon two theories have been proposed. One is based upon the chemical reaction between the soil and solution with an exchange of bases; and, the other is based upon a physical selective adsorption of the base of the salt with a resulting acid which dissolves an equivalent amount of soil bases. In the first theory it is assumed that a neutral salt reacts with the polysilicates of the soil with the base becoming fixed, at least at the beginning, and an equivalent quantity of another base being replaced, thus: $Al_x\ Fe_x\ Mg_x\ Na_xCa\ (SiO_3)_x\ (H_2O)_x + 2\ KCl = Al_x\ Fe_x\ Mg_x\ Na_x\ K_2\ (SiO_3)_x\ (H_2O)_x + CaCl_2$. This equation typifies the metathetical reaction that may take place between a neutral salt and the zeolitic compounds of the soil. The $CaCl_2$ or any other salt formed is supposed to be in solution.

The fixation of the soluble phosphates is supposed to be accomplished by the bases present in the soil such as iron, aluminum, calcium, etc. The reaction which is different from the above is typified by the follow-

ing equation $CaH_4(PO_4)_2 + CaCO_3 = Ca_2H_2(PO_4)_2 + CO_2 + H_2O$. $Ca_2H_2(PO_4)_2 + CaCO_3 = Ca_3(PO_4)_2 + CO_2 + H_2O$. The soluble phosphate, therefore, reacting with calcium forms insoluble $Ca_3(PO_4)_2$.

According to the selective adsorption theory (19) it is suggested that when a soil is in contact with a solution such as KCl it adsorbs the K ion at much greater rate or greater proportion than the Cl ion, thereby, (since an equivalent number of hydroxyl ions are also removed with the potassium ions), causing a partial hydrolysis of the solution, (KCl plus $HOH = KOH$ (adsorbed) + HCl), and leaving free acid in the solution which goes to dissolve the bases in the soil.

Although the last theory might be correct yet it has not been absolutely proven and does not account for all the facts. The first or chemical theory, however, which seems more rational explains practically all facts quite satisfactorily and is probably more widely accepted. In the light of this theory the answer to the above question as to how the increase in concentration of the soil solution by the application of salts is brought about and what the composition of the resulting solutions is may be found in the assumption that similar chemical reactions as shown above took place between the constituents of the soil and the salt solution added with the formation of entirely new compounds which have a smaller than, or as great, lowering of the freezing point as the salt solutions added, and that not any of the salt solutions added may exist in the original form in the resulting solution, except possibly in the artificial inert substances such as the quartz sand, kaolin, burned soils, etc. In these latter substances the entire original concentration of the salt solutions was imparted to them and remained almost unaltered.

The almost complete disappearance of the original concentration of the $CaH_4(PO_4)_2$ and K_2HPO_4 solutions in the agricultural soils tends to confirm the equation given above which shows that these compounds react with the bases of the soil and form insoluble substances and thus the concentration of the soil solution is very little if any increased either directly by these compounds or by the formation of new compounds, as in the case of the neutral salts.

The results obtained with the acids can be explained under the same basis as those of the salts. These acids reacted with the bases of the soils and formed salts. The degree of concentration imparted to the soil solution depends upon the freezing point depression of the salt which in turn depends upon the amount of the salt in solution and its degree of dissociation. The slight or negligable increase in concentration which the oxalic acid caused in the agricultural soils and especially in the heavier types, suggests the idea that the compound formed was more or less insoluble, similar to the case of the acid phosphate salts. The increase in concentration of the acietic acid above that of the original concentration of the acid itself signifies that either this acid formed a compound in large quantity or one which had a far greater degree of dissociation than the acid itself. The latter assumption is more probable.

Finally, it should be remembered in drawing conclusions concerning the effect of the application of salts and acids upon the concentration of the soil solution that the lowering of the freezing point which is em-

(19) Parker, Jour. Agr. Res., V. 1 No. 3, 1913.

ployed to determine the increase in concentration, is produced mainly by two factors, first by the amount of soluble material present, and second by the degree of dissociation of this material. The last factor undoubtedly plays an appreciable role.

SUMMARY.

The work previously reported upon the freezing point method as a new means of measuring the concentration of the soil solution directly in the soil has been repeated with new or improved procedures, and greatly extended. The general results of the second study have entirely confirmed those of the first. These results together with the new improvements in the procedure may be summarized as follows:

The new procedure consisted of placing a short column of soil in a glass tube, inserting the bulb of a Beckmann thermometer into this column of soil until it was completely covered. The tube containing the soil and the thermometer was then placed directly in the cooling mixture having a temperature between —2° and —3°C, and the soil allowed to supercool to 1°C. Then the thermometer was moved in the soil in order to start solidification. The temperature was then allowed to rise until it became constant. The thermometer was tapped and the reading recorded.

It was found again that it is extremely easy to determine the freezing-point lowering of soils. The solidification can be started when the soil mass is supercooled to only about 0.3°C and it is far easier to induce solidification in soils than in pure solutions or soil water extracts. The depression of the freezing point of soils can be measured from any maximum water content to a very low water content. Below this minimum of moisture, solidification cannot be induced to take place, at least very readily, and the results are not very reliable. The minimum water content seems to lie very close to the wilting coefficient of soils.

The freezing-point lowering has been measured in over 58 soils at two different moisture contents—very low and very high. These soils included characteristic types of 10 different states, Rhode Island, Pennsylvania, Michigan, Kentucky, Florida, Texas, Wisconsin, Minnesota, Washington, and California. The purpose of employing typical soils from all these states was to ascertain the concentration of the soil solution by means of the freezing point method. The results obtained from this study show (1) that the lowering of the freezing point of soils is entirely different at the two moisture contents in all the different soils. (2) The degree of the freezing-point lowering is quite small at the high moisture content and varies rather appreciably in the different soils, while at the low moisture content it is tremendously high and varies considerably in the various soils. At the maximum percentage of water the lowering of the freezing point varies from 0.010°C in the case of some sands to 0.075°C in the case of some clay loams, and clays, while at the minimum percentage of moisture it ranges from about 0.110°C in some sands to about 1.370°C in some of the loams and clays. The degree of depression for heavy sandy loams, silts, clay loams, and clays tends to

be above 1°C at the minimum water content while that of sands and very light sandy loams lies as a rule close to 0.4°C. Since, however, water appears to influence greatly the lowering of the freezing point it cannot always be said that these values of the depression represent absolute relative amounts of salts between the different soils, and especially between the related types of soil. A true comparison of the relative salt content of soils can be ascertained only when the free water content of the various soils is exactly at the equivalent point.

In all the soils, with the exception of quartz sand and of some extreme types of sand, the ratio of the freezing point lowering is not directly inversely proportional to the ratio of the percentage of water as might be expected (approximately), but the former is many times greater than the latter. Thus, in the case of one of the clay loams the ratio between the lowering of the freezing point and water content is 27.56 and 2.37, respectively. Upon investigating this relation more thoroughly by determining the depression of various soils at a large number of moisture contents it was found that this relation follows a mathematical law and indeed the geometric law, that is, the freezing point depression increases in a geometric progression while the percentage of water decreases in an arithmetic progression. In the case of quartz sand, however, the depression increases directly inversely proportionally to the water content.

The unusual rapid increase in the depression with the diminution in the percentage of water content and the extraordinary high lowering of the freezing point at the low water content created at first some doubts as to whether these freezing-point lowerings are really caused by concentration of the soil solution and not by some physical factors. If they are caused by some physical factors they do not represent concentration of solution. Two physical factors which might produce such results it was thought, are (1) the supposed pressure with which the water films are held by the soil particles, and (2) the influence of the soil particles themselves upon the depression. These and other possible physical factors have been thoroughly considered but it has not become apparent that the depressions of the freezing point as obtained are influenced by any physical agent. On the contrary all evidences, both direct and indirect, point overwhelmingly to the fact that the values of the freezing point lowering at the different moisture contents are caused by and represent actual concentration of solution.

In explaining that the high depression of the freezing point at the low moisture content or the increase of the depression with the decrease in the percentage of water, may represent concentration of solution, the following suggestion is offered: It is assumed that the soil solution contains salts or their ions, produced by the reaction of the dissolved components of the soil minerals, hydrolysis of the minerals, application of fertilizers, decomposition of organic matter, etc. These salts have, as a rule, a high solubility and would require a large amount of them to form a saturated solution. They are formed slowly and since the frequent and excessive rains, especially in the humid regions, tend to leach them away, only a relatively small amount of them is present at any one time. At a high moisture content these salts are diluted and the lowering of the freezing point is small. As the moisture content, however, is reduced

they are concentrated and the lowering of the freezing point becomes greater.

A critical consideration of the character of the soil system and a thorough examination of the available data of the soil solution as obtained through soil water extracts, drainage water, etc., lend considerable support to this hypothesis.

It appears very reasonable also to suppose that the solubility constant or product of a solid substance is different when the material is in contact with water in the film than in the mass form.

The foregoing hypotheses, however, do not explain why the lowering of the freezing point of the agricultural soils increases in a geometric progression while the water content decreases in an arithmetic progression, and does not follow an inverse proportionality law (approximately) as might be expected.

In explanation of this phenomenon the hypothesis is also offered that some of the water contained by the soil is either loosely chemically combined or physically adsorbed or both, in which event this portion of the water is not free or available to act as a solvent but is removed from the liquid phase and takes no part in the lowering of the freezing point. Under this assumption the results are easily explained. Thus, for example, if a clay causes 15% of the water to become inactive or unavailable and at 39% of moisture this clay gives a depression of .075°C and at 22%, .987°C, then at the first case there is 24% of moisture to dissolve the salts while in the second case there is only 7% of moisture for the same purpose. The depression of the freezing point at the low moisture content, therefore, would be many times greater than that at the high moisture content, than would be expected from the total percentage of moisture.

There is a tremendous amount of evidence which appears to prove beyond any doubt that the soils cause water to become inactive or unavailable, and that the quantity varies with the character of the soil, being smallest in the sandy types and largest in the colloidal types. Hence, the foregoing hypothesis seems to be valid.

It was found that the magnitude of the lowering of the freezing point of soils at the low moisture content decreases with successive freezings. This was true, however, with the agricultural soils, but not with artificial substances such as quartz sand, kaolin, burned soils, etc. For explaining these phenomena the hypothesis is offered that the greatest portion of the water which is made inactive or unavailable and thus removed from the field of action as far as the freezing-point lowering is concerned, is due to the colloids which the soils contain. This inactive or unavailable water may exist in the colloids both as loosely chemically combined, and as physically absorbed. Upon freezing these colloids coagulate and the bonds uniting them with the water break and the inactive or unavailable water becomes liberated. This liberated water acts as a solvent and goes to dilute the original solution and thereby decreases the freezing point depression. Thus, for instance, if there were only 5% of moisture at the beginning of the first freezing, there is probably 7% at the end of the first freezing, 7.5% at the end of the second freezing, and so on until all the colloids are coagulated. These soils in which the depression remains constant with successive freezings probably do not contain colloids or if they do they are not coagulable.

The above hypothesis is supported by an overwhelming amount of evidence and consequently it also appears to be valid.

The percentage of moisture content at which solidification refuses to take place very readily is almost the same as that at which plants begin to wilt. From this it becomes evident that the wilting coefficient of soils can be determined by the freezing point method.

In view of the great concentration of the soil solution at the wilting coefficient, it seems logical to conclude that the wilting of plants, is partly due also to the concentration of the soil solution.

By means of the freezing point method the effect of application of soluble salts and acids upon the concentration of the soil solution in the soil was also studied. The results pertaining to the soluble salts show that the different compounds employed have an entirely different effect upon the concentration of the solution of the diverse classes of soil. In the case of the neutral salts the solution of the agricultural soils was increased from 35 to 100% of their added strength, while in the case of the phosphate salts only a very small portion of their concentration was added to the soil solution, amounting in the majority of cases to only 10%. All the salts including the phosphates behaved the same in regard to the artificial substances, the quartz sand, kaolin, burned soils, etc., as they all increased the concentration of their solution to about the same degree, 100%. The neutral salt solutions did not behave uniformly in the different types of soil, some of the salts produced the greatest increase in concentration in the sands and the smallest in the clays, while other salts caused about the same degree of concentration in all the distinct types of soil.

The different acids affected the concentration of the soil solution very differently. Some of the acids augumented the concentration of the solution of the agricultural soils from 50 to 70% of their added strength, others about 130%, and still others only about 5%.

The increase in concentration of the soil solution as produced by the application of the salts and acids is due to the formation of new substances, the depression of the freezing point of which is as great, greater, or less than that of the original substance. In the case of the artificial substances such as quartz sand, kaolin, burned soils, etc., both the original concentration and composition of the salt solutions remained practically unaltered.

FOREWORD.

Technical Bulletin No. 32.

The bovine infectious abortion problem has been studied in our laboratory under the direction of Mr. Cooledge who has charge of the project, "The Effect of Diseases in the Cow on the Milk." Mr. Huddleson, assisting in carrying out the details of the general plan, has undertaken to determine the extent of injury inflicted upon the calf as a result of the ingestion of milk known to be infected, naturally or otherwise, with *Bacterium abortus*. This is a matter of the gravest importance to the whole cattle industry. The results recorded in this paper, made possible by methods of study evolved in this laboratory, contradict certain impressions that are gaining ground amongst those in a position to offer treatment for the disease in question. Fortunately Mr. Huddleson is in a position to pursue his studies in this connection with increased vigor.

WARD GILTNER.

THE TRANSMISSION OF *BACT. ABORTUS* (BANG) TO NEW BORN CALVES THROUGH THE INGESTION OF MILK.

BY I. F. HUDDLESON.

Numerous investigations have demonstrated the infectiousness for animals of milk containing pathogenic microorganisms. The occurrence of *Bact. abortus* in the milk from apparently normal cows has been demonstrated by Schroeder and Cotton (1), Evans (2), and Cooledge (3). The pathogenicity of milk containing *Bact. abortus* for guinea pigs by the inoculation route has also been demonstrated by the above investigators. The possibility of transmitting the infection to calves through the ingestion of milk has not been conclusively demonstrated. Williams (4) was the first investigator to publish experimental data concerning the transmission of *Bact. abortus* to calves through the ingestion of raw milk. He further associates the disease called infectious abortion with white scours, acute or chronic vaginitis, pneumonia, and matting of the hairy tufts about the orifice of the sheath and at the lower commissure of the vulva of calves. His experimental data are as yet inconclusive.

Up to the present time, there seems to have been more or less speculative consideration of the subject with little attempt to approach the problem by actual experiments. The present study details a series of experiments which were devised in the hope of throwing light on the subject.

TECHNIQUE EMPLOYED.

In view of the fact that Cooledge (3) has shown that milk containing agglutinins for *Bact. abortus* may contain the bacterium, the agglutination test was used in studying the milk fed to the animals. The infectiousness of the milk was further controlled by guinea pig inoculations.

The term "naturally infected milk" which will be used in this paper, implies a milk reacting positively to the agglutination test using *Bact. abortus* as antigen and "non-infected milk" implies a non-reacting milk.

The calves used in the experiment (excepting those fed non-infectious milk) were separated from their respective dams shortly after birth in order to safeguard against a possible infection from infectious material which might have collected on the surface of the udder or teat. The calves were fed about one gallon of milk from a pail twice daily. Every precaution was taken to guard against an infection other than from the milk.

The results of the feeding of the milk were studied by means of the agglutination and complement fixation tests upon the blood sera of the calves, using *Bact. abortus* as antigen. The calves were bled from the jugular vein periodically at intervals of about one week and the blood sera tested.

Observations and microscopical examinations for matting and staining of the sexual hairs of the calves were made during the course of the feeding.

In the course of the experiment eight calves were fed upon naturally infected milk and six calves were fed upon non-infected milk. The calves fed non-infected milk were not separated from their respective dams at the time of birth, but were allowed to remain and suckle for three days and then separated. A control was fed pasteurized naturally infected milk in order to compare the result with those fed upon raw naturally infected milk. A second control was fed upon non-infected milk plus five cubic centimeters of a 48-hour bouillon culture of *Bact. abortus* with each feeding in order to compare the result from feeding naturally infected milk with that of artificially infected milk.

As accurately as possible the history of each dam was obtained showing the number of normal parturitions, the number of abortions and the blood and milk reactions to the agglutination and complement fixation tests at the time of parturition or abortion. The history of the dams is summarized in Table I.

FEEDING EXPERIMENTS.

Bull calf 995 A, Table II, was fed upon naturally infected milk for a period of thirteen weeks. The blood of the calf was negative before feeding milk. A slight reaction developed one week after feeding. A high antibody index developed at the end of the second week, and remained constant until the end of the third week. The blood was negative when tested at the end of the fourth week. The blood remained negative during the remainder of the time feeding was continued. No matting or staining of the sexual hairs about the sheath occurred during the time the calf was fed upon milk. Approximately three weeks after the feeding of milk was discontinued, the sexual hairs became matted and stained a brownish black. A microscopical examination of sediment collected from the matted hairs revealed only epithelial cells, uric acid crystals and many bacteria. No pus cells were found in the sediment. The dam of calf 995 A was about two years old at the time of this parturition. The blood of the dam was negative before parturition, but positive after parturition. The milk was positive before and after parturition. The milk produced lesions and *Bact. abortus* antibodies when inoculated intraperitoneally into guinea pigs: Calf 995 A was fed upon this milk.

Heifer calf 996 A, Table 3, was fed upon naturally infected milk for a period of ten weeks. The blood of the calf was negative before feeding. The blood remained negative throughout the time of feeding. The sexual hairs below the vulva remained distinctly separate and unstained during the time milk was fed. The dam of calf 996 A was two years old at the time of this parturition. The blood and milk of the dam were negative before parturition. The milk became positive after parturition, the reaction remaining only two weeks. The blood remained negative.

Bull calf 997 A, Table 4, was fed upon naturally infected milk for a period of two weeks. The calf died of acute intoxication in the third week of feeding. The blood of the calf was negative before feeding.

Only a slight reaction developed. The sexual hairs developed no matting or staining. The dam of calf 997 A was two years old at the time of the parturition. The milk and blood of the dam gave a negative reaction before and after parturition.

Heifer calf 1000 A, Table 5, was fed upon naturally infected milk for a period of fourteen weeks. The blood was negative before feeding the milk, and continued to remain negative throughout the period of feeding. No matting of the sexual hairs below the vulva was observed. The dam of calf 1000 A was two years old at the time of this parturition. The blood and milk of the dam were negative before and after parturition.

Bull calf 1001 A, Table 6, was fed upon naturally infected milk for a period of five weeks. The blood of the calf gave a positive reaction before feeding. The positive reaction persisted for three weeks. The sexual hairs around the sheath became slightly matted the second week of feeding. A microscopical examination of the sediment collected from the matted hairs revealed only bacteria, uric acid crystals and epithelial cells. The dam of calf 1001 A was seven years old at the time of this parturition. The cow has never aborted or had an abnormal parturition. The blood was negative and the milk was positive after parturition.

Bull calf 1002 A, Table 7, was fed upon non-infected milk for the first week after birth and then fed upon naturally infected milk for thirteen weeks. The blood was negative before feeding milk and continued to remain negative throughout the period of feeding. The sexual hairs about the sheath developed a slight matting and brownish black staining in the fourth week. The matting was not consistent. The hairs would mat together after urination, but would separate again on drying. Several microscopic examinations were made of the washings from the sexual hairs. No pus cells were found. The dam of calf 1002 A was five years old at the time of this parturition. The cow has never aborted or had an abnormal parturition. The blood and milk of the cow were negative before and after parturition.

Bull calf 100 A, Table 8, was allowed to suckle its mother for three days after birth and then separated. The calf has since been receiving naturally infected milk. The calf was bled three days after birth at which time a positive reaction was obtained. The positive reaction persists at this writing. The sexual hairs have remained unmatted and unstained. The dam of calf 100 A was three years old at the time of this parturition. The calf of the first pregnancy was aborted. The blood and milk of the cow were positive after parturition.

Bull calf 101 A, Table 9, was allowed to suckle its mother for three days after birth at which time it was separated and fed upon naturally infected milk. The blood of the calf has repeatedly given a negative reaction. The sexual hairs have remained unmatted and unstained. The dam of calf 101 A was two years old at the time of this parturition. The blood and milk of the cow gave a negative reaction before and after parturition.

Heifer calf 102 A, Table 10, was fed upon naturally infected milk for a period of fifteen weeks. The blood of the calf was negative before feeding milk. No test was made in the first week after feeding was begun. Positive agglutination and complement fixation reactions were obtained

in the second week. A slight reaction persisted for six weeks. Succeeding tests since the sixth week have been negative. No matting of the sexual hairs below the vulva occurred during the feeding of milk. The dam of calf 102 A was three years old at the time of this parturition. The cow has never aborted or had an abnormal parturition. The cow was injected subcutaneously with five cubic centimeters and ten cubic centimeters of a killed suspension and twenty c.c. of a live suspension of *Bact. abortus* at ten day intervals during the seventh month of gestation. The blood of the cow was positive to the agglutination and complement fixation tests at the time of parturition. The milk was also positive to both tests.

Heifer calf 103 A, Table 11, was fed upon naturally infected milk for six weeks. Complement fixing antibodies were present in the blood of the calf a few hours after birth. Agglutinins appeared in the fourth week. The positive reaction persisted for six weeks. The calf died in the seventh week of white scours. No matting of the sexual hairs below the vulva was observed. The dam of calf 103 A was three years old at the time of this parturition. This parturition was premature, being about two weeks before time. The dam was treated during the eighth month of gestation, in the same manner as dam 102. The blood and milk of the cow contained agglutinating and complement fixing bodies at the time of the parturition.

Bull calf 104 A has been receiving naturally infected milk for thirteen weeks. The blood has never given a positive reaction to the agglutination or complement fixation tests. The sexual hairs around the prepuce have never shown any matting or staining. The dam of calf 104 A was two years old at the time of this parturition. The blood and milk of the cow have never given a positive reaction to the agglutination or complement fixation tests.

In order to compare a possible blood reaction due to a naturally infected milk with that due to an artificially infected milk, a calf was fed upon non-infected milk plus a culture of *Bact. abortus*.

Bull calf 1003 A, Table 13, was fed upon non-infected milk plus five cubic centimeters of a forty-eight hour bouillon culture of *Bact. abortus* (the culture being added to the milk at each feeding) for a period of twelve weeks. The blood of the calf was negative before feeding the mixture. A high antibody index developed at the end of the first week of feeding. The antibody index remained constant until the end of the fourth week. At this time the antibody index began to decrease. On the ninth week the blood was negative and has remained negative up to the time of this writing. A distinct matting and staining of the sexual hairs around the sheath appeared in the twelfth week of feeding. A microscopic examination of the hairs revealed epithelial cells, uric acid crystals, and many bacteria. No pus cells were found. The dam of calf 1003 A was four years old at the time of this parturition. The calf of the second pregnancy was aborted. The blood and milk were negative before parturition. The cow died of milk fever shortly after parturition and consequently no post parturition tests were made.

In order to maintain a control on the naturally infected milk fed to calves, the infected milk was pasteurized at a temperature of 63°C. for fifteen minutes. The milk was then fed to a calf. A temperature of

63°C. for fifteen minutes has no effect upon the *Bact. abortus* antibodies, but is sufficient to destroy all of the abortion bacteria present.

Heifer calf 999 A, Table 14, was fed upon pasteurized naturally infected milk for a period of thirteen weeks. The blood reaction was negative before feeding and remained negative throughout the time of feeding. No matting of the sexual hairs below the vulva was observed. The dam of calf 999 A was two years old at the time of this parturition. The blood and milk of the cow were negative before and after parturition.

THE RESULTS OF FEEDING NON-INFECTED MILK.

Bull calf 1004 A, Table 15, was fed upon non-infected milk for a period of twelve weeks. The blood of the calf gave a positive reaction before feeding milk. The reaction persisted for three weeks. The sexual hairs remained unmatted and unstained during the feeding. The dam of calf 1004 A was eight years old at the time of this parturition. The calf of the second pregnancy was aborted. The milk and blood of the cow were negative before parturition. The blood was negative after parturition. The milk was positive.

Heifer calves 1005 A, Table 16, and 1006 A, Table 17, were fed upon non-infected milk for a period of twelve weeks. The blood sera of both calves were negative before feeding. They have continually given a negative reaction. The sexual hairs below the vulvae of the calves remained unmatted and unstained. The dam of calf 1005 A was three years old at the time of this parturition. The dam of calf 1006 A was seven years old. The blood and milk of each cow were negative before and after parturition.

Bull calf 1007 A, Table 18, was fed upon non-infected milk for a period of twelve weeks. The blood sera of the calf was not tested until two weeks after birth. The blood has continually given a negative reaction. The sexual hairs remained unmatted and unstained during the feeding. The dam of calf 1007 A was six years old at the time of this parturition. The calf of the second pregnancy was aborted. The blood and milk of the cow gave negative reactions after parturition.

Heifer calf 1008 A, Table 19, was allowed to suckle her dam for three days after birth. The calf was then separated and fed upon non-infected milk for twelve weeks. The blood of the calf gave a positive reaction when the first test was made, 57 days after birth. The positive reaction persisted for five weeks. The sexual hairs remained unmatted and unstained. The dam of calf 1008 A was three years old at the time of this parturition. The milk and blood gave positive reactions when tested after parturition. The milk of this cow has given a positive reaction for more than eighteen months.

Heifer calf 1009 A, Table 20, was allowed to suckle her dam for three days after birth and then separated. The calf was then fed upon non-infected milk for a period of twelve weeks. The first blood test was made when the calf was seventeen days old. The blood gave a positive reaction which persisted for four weeks. The sexual hairs remained unmatted and unstained. The dam of calf 1009 A was two years old at the time of this parturition. The blood and milk of the cow gave positive reactions before and after parturition.

DISCUSSION.

From the data presented in the foregoing pages, it is apparent first of all, that the results have an important bearing upon the appearance of agglutinating and complement fixing bodies in the blood of calves as a result of ingesting naturally infected milk. The results show that out of eleven calves fed upon naturally infected milk for a long period of time, the blood of only one (calf 995 A, Table 2) developed complement fixing bodies to any marked degree. The calf was fed upon naturally infected milk for thirteen weeks. The blood was tested at intervals of about one week, by means of the agglutination and complement fixation tests. Complement fixing bodies were present in the blood for the first five weeks. All succeeding tests have given negative reactions. It is apparent that the blood of calf 102 A gave a weak positive reaction after the feeding of milk was begun. The investigations of Cooledge (7) seem to show that agglutinating and complement fixing antibodies for *Bact. abortus* may be absorbed through the large intestine of humans as a result of ingesting milk containing such antibodies. Talmon and Castaigne (8) have demonstrated the appearance of agglutinating antibodies in the blood of a child who was nursing a mother affected with typhoid fever. In a similar case they failed to demonstrate agglutinating antibodies in the blood of the child. Agglutinating antibodies were present in the breast milk of the mothers. They account for the appearance of antibodies in the first case from the fact that the child was suffering from enteritis. They further state that antibodies are not absorbed by mucous cavities unless a lesion is present. The appearance of antibodies in the blood of calf 102 A may be accounted for in a similar manner, as this calf was suffering from a severe case of diarrhea at the time antibodies made their first appearance. The remaining calves (excepting calf 100 A) fed upon naturally infected milk has never given a positive reaction. The blood of calf 100 A was not tested until three days after birth. Complement fixing bodies were present at this time. This positive reaction is not due to an infection from the milk. This statement is based on experiments of the writer which demonstrate the time of appearance of agglutinating and complement fixing bodies for *Bact. abortus* after subcutaneous injections of a live suspension of the organisms. From eight to twelve days elapse before the appearance of antibodies after an injection.

The calves fed upon non-infected milk (excepting calf 1001 A) gave no positive serum reactions. The blood serum of calf 1004 A possessed complement fixing bodies at birth. The blood gave a positive reaction for three succeeding weeks.

It is evident from the results reported in Table 10, that antibodies will develop in the blood of a calf when fed continually upon milk mixed with a culture of *Bact. abortus*. The positive reaction does not persist for a great length of time, but disappears while the mixture is being fed.

Examination of Tables 6 and 12, reveals the fact that the blood sera of calves may give a positive reaction at birth. The positive reaction may be due to an active infection, or to a passive transmission of complement fixing bodies present in the blood of the mother, to the fetus in utero. Regarding the latter statement Pfoundler (5) says that antibodies circulating in the body of the mother have not been proved to

pass through the placenta into the body of the fetus, even if the mother becomes immune to the disease. However, he says this may occur from pathological changes in the placenta and from the presence of the antigen in the placenta which serves to stimulate the production of antibodies that pass into the circulation of the fetus. In order to throw more light on the statement made by Pfoundler, three pregnant cows were injected subcutaneously and intravenously first with five and ten cubic centimeters of a killed suspension and then twenty cubic centimeters of a live suspension of *Bact. abortus* at intervals of ten days during their seventh month of gestation. One of the cows aborted during the eighth month of gestation, one gave birth to a premature living calf and the remaining cow had a normal parturition. The blood sera of the dams reacted strongly to the agglutination and complement fixation tests. The blood sera of two of the calves gave a negative reaction at birth. The blood serum of the premature calf gave a positive reaction. Altho these results are limited, it readily appears that antibodies circulating in the body of the mother are not transmitted to the fetus in utero under normal conditions. Marshall (6) says that it has been shown by means of precipitin reaction, that if egg-albumin is injected into the mother some of it passes unchanged to the fetus. On the other hand, the proteins of ox-serum cannot be recognized in the fetal blood, even when a considerable quantity is injected into the mother (rabbit).

A very interesting occurrence is to be noted in connection with calves that possess antibodies in their blood at birth. In every instance in which the blood of the offspring was positive, the milk of the dam was positive. Furthermore, *Bact. abortus* was demonstrated present in the milk of the dams by means of guinea pig inoculations. Would this occurrence indicate that an infection of the udder travels to the uterus through the blood or lymphatic system? This question cannot be answered at the present writing.

The results shown in Tables 16 and 17, clearly emphasize the necessity of testing the blood of calves at birth in experiments of this nature. It would not be logical to assume that these calves acquired the positive reactions as a result of ingesting infected milk since the blood sera of the calves were not tested until after they had received milk. This precaution has not been observed in similar researches by others.

A study of the tables reveals the fact that a larger number of positive reactions was obtained with the complement fixation test than with the agglutination test. In fact, erroneous conclusions would have been drawn from the results had not the complement fixation test been employed in this study.

The matting and staining of the preputial hairs of bull and heifer calves is a subject to which much importance has been attached by Williams (4) in his investigations. He concludes from his observations that calves fed upon raw milk in almost every instance acquired a matting and staining of the sexual hairs from thirty to sixty days after birth. He further believes that *Bact. abortus* may be the cause of this phenomenon.

The observations made in this study do not confirm similar observations made by Williams. In very few instances, has there been a mat-

ting of the sexual hairs observed, in which instances the matting could not be attributed to *Bact. abortus*.

CONCLUSIONS.

Agglutinating and complement fixing bodies for *Bact. abortus* are very rarely demonstrated in the blood of calves as a result of ingesting naturally infected milk.

Calves may give a positive reaction to the complement fixation test immediately after birth. The reaction probably signifies a pre-natal infection.

There is favorable evidence that antibodies circulating in the body of the mother are not transmitted to the fetus in utero.

The data strongly emphasize the necessity of testing the blood of calves at birth in order to differentiate between positive reactions that may be due to the ingestion of milk and positive reactions that may be present at birth.

There appears to be no connection, whatever, between the feeding of milk and the matting and staining of the sexual hairs of new born calves.

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8. Talamon and Castaigne. Obstetrique, Paris, cf. ibid., p. 58, 1898.

TABLE I.—SHOWING THE HISTORY OF THE DAMS OF THE CALVES USED IN THE FEEDING EXPERIMENT.

Dam No.	Age.	Number of normal births.	Number of abortions.	Reaction of blood before last parturition or abortion.	Reaction of blood after last parturition or abortion.	Reaction of milk after freshening.
995	2	One..........	None........	Negative.....	Positive......	Positive.
996	2	One..........	None........	Negative.....	Positive......	Positive.
997	2	One..........	None........	Negative.....	Negative.....	Negative.
1000	2	One..........	None........	Negative.....	Negative.....	Negative.
1001	7	Five.........	None........	No test made.	Negative.....	Positive.
1002	5	Three........	None........	No test made.	Negative.....	Negative.
1003	4	Two.........	2nd calf......	Negative.....	No test made.	No test made.
1004	8	Six..........	2nd calf......	No test made	Negative.....	Positive.
1005	2	One..........	None........	No test made.	Negative.....	Negative.
1006	7	Four.........	None........	No test made.	Negative.....	Negative.
1007	9	Six..........	2nd calf......	No test made.	Negative.....	Negative.
1008	5	Three........	None........	No test made.	Positive......	Positive.
1009	3	Two.........	None........	Positive......	Positive......	Positive.
100	3	One..........	One..........	No test made.	Positive......	Positive.
101	2	One..........	None........	Negative.....	Negative.....	Negative.
102	3	One..........	None........	Positive......	Positive......	Positive.
103	2	One..........	None........	Positive......	Positive......	Positive.
104	2	One..........	None........	Negative.....	Negative.....	Negative.

TABLE 2.

THE RESULT OF FEEDING NATURALLY INFECTED MILK TO A NEW BORN CALF.

Reaction of blood serum.	Date.	Bull Calf 995A. (a)								
		Agglutination.					Comp.		Fix.	
		.1	.05	.025	.01	.005	.1	.04	.02	.005
Before feeding...........	1-15-16	—	—	—	—	—	—	—	—	—
1st week after feeding....	1-22-16	p	—	—	—	—	+	+	p	—
2nd week after feeding...	1-29-16	p	—	—	—	—	+	+	p	—
3rd week after feeding...	2- 5-16	p	—	—	—	—	+	+	p	—
4th week after feeding...	2-12-16	—	—	—	—	—	—	—	—	—
5th week after feeding...	2-19-16	—	—	—	—	—	—	—	—	—
6th week after feeding...	2-26-16	—	—	—	—	—	—	—	—	—
7th week after feeding...	3- 4-16	—	—	—	—	—	—	—	—	—
8th week after feeding...	3-11-16	—	—	—	—	—	—	—	—	—
9th week after feeding...	3-18-16	—	—	—	—	—	—	—	—	—
10th week after feeding...	3-25-16	—	—	—	—	—	—	—	—	—
11th week after feeding...	4- 1-16	—	—	—	—	—	—	—	—	—
12th week after feeding...	4- 8-16	—	—	—	—	—	—	—	—	—
13th week after feeding...	4-15-16	—	—	—	—	—	—	—	—	—
(b) 14th week after feeding	4-22-16	—	—	—	—	—	—	—	—	—
17th week after feeding...	5-11-16	—	—	—	—	—	—	—	—	—
20th week after feeding...	6- 3-16	—	—	—	—	—	—	—	—	—
22nd week after feeding...	6-15-16	—	—	—	—	—	—	—	—	—
25th week after feeding...	7-10-16	—	—	—	—	—	—	—	—	—
37th week after feeding...	10-15-16	—	—	—	—	—	—	—	—	—
41st week after feeding....	11-15-15	—	—	—	—	—	—	—	—	—
48th week after feeding...	1- 7-17	—	—	—	—	—	—	—	—	—
51st week after feeding....	1-25-17	—	—	—	—	—	—	—	—	—
52nd week after feeding...	2- 1-17	—	—	—	—	—	—	—	—	—
56th week after feeding...	3- 1-17	—	—	—	—	—	—	—	—	—
60th week after feeding...	4- 1-17	—	—	—	—	—	—	—	—	—

(a) Born 1-15-16.
(b) On this date feeding of milk was discontinued.

TABLE 3.

THE RESULT OF FEEDING NATURALLY INFECTED MILK TO A NEW BORN CALF.

Reaction of blood serum.	Date.	HEIFER calf 996A. (a)								
		Agglutination.					Comp. Fix.			
		.1	.05	.025	.01	.005	.1	.04	.02	.005
Before feeding...........	5-28-16	—	—	—	—	—	—	—	—	—
1st week after feeding....	6- 5-16	—	—	—	—	—	—	—	—	—
2nd week after feeding...	6-12-16	—	—	—	—	—	—	—	—	—
3rd week after feeding...	6-19-16	—	—	—	—	—	—	—	—	—
4th feed after feeding....	6-26-16	—	—	—	—	—	—	—	—	—
5th week after feeding...	7- 3-16	—	—	—	—	—	—	—	—	—
6th week after feeding...	7-10-16	—	—	—	—	—	—	—	—	—
7th week after feeding...	7-17-16	—	—	—	—	—	—	—	—	—
8th week after feeding...	7-24-16	—	—	—	—	—	—	—	—	—
9th week after feeding...	7-31-16	—	—	—	—	—	—	—	—	—
10th week after feeding...	8- 7-16	—	—	—	—	—	—	—	—	—
11th week after feeding...	9-14-16	—	—	—	—	—	—	—	—	—
12th week after feeding...	9-21-16	—	—	—	—	—	—	—	—	—

(a) Born 5-28-16.

TABLE 4.

THE RESULT OF FEEDING INFECTED MILK TO A NEW BORN CALF.

Reaction of blood serum.	Date.	Bull Calf 997A. (a)								
		Agglutination.					Comp. Fix.			
		.1	.05	.025	.01	.005	.1	.04	.02	.005
Before feeding...........	2- 5-16	—	—	—	—	—	—	—	—	—
1st week after feeding...	2-12-16	—	—	—	—	—	p	—	—	—
2nd week after feeding..	2-19-16	—	—	—	—	—	—	—	—	—
3rd week after feeding..	(b)									

(a) Born 2-5-16.
(b) Died of acute intoxication 2-21-16.

TABLE 5.

THE RESULT OF FEEDING NATURALLY INFECTED MILK TO A NEW BORN CALF.

Reaction of blood serum.	Date.	Heifer calf 1000A. (a)								
		Agglutination.					Comp.		Fix.	
		.1	.05	.025	.01	.005	.1	.04	.02	.005
Before feeding...........	2-25-16	–	–	–	–	–	–	–	–	–
1st week after feeding....	3- 3-16	–	–	–	–	–	–	–	–	–
2nd week after feeding...	3-10-16	–	–	–	–	–	–	–	–	–
3rd week after feeding...	3-17-16	–	–	–	–	–	–	–	–	–
4th week after feeding...	3-24-16	–	–	–	–	–	–	–	–	–
5th week after feeding...	3-31-16	–	–	–	–	–	–	–	–	–
6th week after feeding...	4- 7-16	–	–	–	–	–	–	–	–	–
7th week after feeding...	4-14-16	–	–	–	–	–	–	–	–	–
8th week after feeding..	4-21-16	–	–	–	–	–	–	–	–	–
9th week after feeding...	4-28-16	–	–	–	–	–	–	–	–	–
10th week after feeding...	5- 5-16	–	–	–	–	–	–	–	–	–
11th week after feeding...	5-12-16	–	–	–	–	–	–	–	–	–
12th week after feeding...	5-26-16	–	–	–	–	–	–	–	–	–
(b) 13th week after feeding.	6- 2-16	–	–	–	–	–	–	–	–	–
15th week after feeding...	6-15-16	–	–	–	–	–	–	–	–	–
20th week after feeding...	7-10-16	–	–	–	–	–	–	–	–	–
28th week after feeding...	9-14-16	–	–	–	–	–	–	–	–	–

(a) Born 2-25-16.
(b) On this date the feeding of milk was discontinued.

TABLE 6.

THE RESULT OF FEEDING NATURALLY INFECTED MILK TO A NEW BORN CALF.

Reaction of blood serum.	Date.	Bull calf 1001A. (a)								
		Agglutination.					Comp.		Fix.	
		.1	.05	.025	.1	.005	.01	.04	.02	.005
Before feeding...........	4-26-16	+	p	–	–	–	+	+	p	–
1st week after feeding....	5- 6-16	+	–	–	–	–	+	+	+	–
2nd week after feeding....	5-13-16	+	–	–	–	–	+	+	–	–
3rd week after feeding....	5-22-16	–	–	–	–	–	+	–	–	–
4th week after feeding....	5-29-16	–	–	–	–	–	–	–	–	–
(b)5th week after feeding..	6- 5-16	–	–	–	–	–	–	–	–	–

(a) Born 4-27-16.
(b) Killed 6-7-16.

TABLE 7.

THE RESULT OF FEEDING NATURALLY INFECTED MILK TO A NEW BORN CALF.

Reaction of blood serum.	Date.	Bull calf 1002A. (a)								
		Agglutination.					Comp.		Fix.	
		.1	.05	.025	.01	.005	.1	.04	.02	.005
Before feeding...........	4-27-16	—	—	—	—	—	—	—	—	—
1st week after feeding....	5- 3-16	—	—	—	—	—	—	—	—	—
2nd week after feeding...	5-10-16	—	—	—	—	—	—	—	—	—
3rd week after feeding...	5-17-16	—	—	—	—	—	—	—	—	—
4th week after feeding...	5-24-16	—	—	—	—	—	—	—	—	—
5th week after feeding...	5-29-16	—	—	—	—	—	—	—	—	—
6th week after feeding...	6- 5-16	—	—	—	—	—	—	—	—	—
7th week after feeding...	6-12-16	—	—	—	—	—	—	—	—	—
8th week after feeding...	6-19-16	—	—	—	—	—	—	—	—	—
9th week after feeding...	6-26-16	—	—	—	—	—	—	—	—	—
10th week after feeding...	7- 3-16	—	—	—	—	—	—	—	—	—
11th week after feeding...	7-10-16	—	—	—	—	—	—	—	—	—
12th week after feeding...	7-17-16	—	—	—	—	—	—	—	—	—
13th week after feeding...	7-24-16	—	—	—	—	—	—	—	—	—
(b)14th week after feeding.	7-31-16	—	—	—	—	—	—	—	—	—
20th week after feeding...	9-14-16	—	—	—	—	—	—	—	—	—
24th week after feeding...	10-15-16	—	—	—	—	—	—	—	—	—
28th week after feeding...	12-15-16	—	—	—	—	—	—	—	—	—
32nd week after feeding...	1-15-17	—	—	—	—	—	—	—	—	—

(a) Born 4-26-16.
(b) On this date the feeding of milk was discontinued.

TABLE 8.

THE RESULT OF FEEDING NATURALLY INFECTED MILK TO A NEW BORN CALF.

Reaction of blood serum.	Date.	Bull Calf 100A. (a)								
		Agglutination.					Comp. Fix.			
		.1	.05	.025	.01	.005	.1	.04	.02	.005
1st test................	11- 6-16	−	−	−	−	−	+	+	+	+
1st week after feeding....	11-13-16	−	−	−	−	−	+	+	+	+
2nd week after feeding...	11-22-16			(lost)			+	+	+	+
3rd week after feeding...	11-29-16	−	−	−	−	−	+	+	+	+
4th week after feeding...	12- 7-16	−	−	−	−	−	+	+	+	+
5th week after feeding...	12-14-16	−	−	−	−	−	+	+	+	+
6th week after feeding...	12-21-16	−	−	−	−	−	+	+	+	+
8th week after feeding...	1- 4-17	−	−	−	−	−	+	+	−	−
9th week after feeding...	1-11-17	−	−	−	−	−	+	+	+	+
10th week after feeding...	1-18-17	−	−	−	−	−	+	+	+	+
11th week after feeding...	1-25-17	−	−	−	−	−	+	+	+	−
12th week after feeding...	2- 1-17	+	+	p	−	−	+	+	+	−
13th week after feeding...	2- 8-17	+	−	−	−	−	+	+	+	−
14th week after feeding...	2-15-17	−	−	−	−	−	+	+	+	−
15th week after feeding...	2-22-17	+	+	+	−	−	+	+	+	−
16th week after feeding...	3- 1-17	−	−	−	−	−	+	+	+	−
17th week after feeding...	3- 8-17	−	−	−	−	−	+	+	−	−
18th week after feeding...	3-15-17	−	−	−	−	−	+	+	+	−
19th week after feeding...	3-22-17	−	−	−	−	−	−	−	−	−
20th week after feeding...	4- 5-17	−	−	−	−	−	−	−	−	−
21st week after feeding....	4-12-17	−	−	−	−	−	−	−	−	−

(a) Born 11-3-16.

TABLE 9.

THE RESULT OF FEEDING NATURALLY INFECTED MILK TO A NEW BORN CALF.

Reaction of blood serum.	Date.	Bull calf 101A. (a)								
		Agglutination.					Comp. Fix.			
		.1	.05	.025	1.01	.005	.1	.04	.02	.005
1st test................	11- 9-16	−	−	−	−	−	−	−	−	−
1st week after feeding....	11-16-16	−	−	−	−	−	−	−	−	−
2nd week after feeding...	11-23-16	−	−	−	−	−	−	−	−	−
3rd week after feeding...	11-29-16	−	−	−	−	−	−	−	−	−
4th week after feeding...	12- 7-16	−	−	−	−	−	−	−	−	−
5th week after serving...	12-14-16	−	−	−	−	−	−	−	−	−
6th week after feeding...	12-21-16	−	−	−	−	−	−	−	−	−
7th week after feeding...	1- 4-17	−	−	−	−	−	−	−	−	−
8th week after feeding...	1-11-17	−	−	−	−	−	−	−	−	−
9th week after feeding...	1-18-17	−	−	−	−	−	−	−	−	−
10th week after feeding...	1-25-17	−	−	−	−	−	−	−	−	−
11th week after feeding...	2- 1-17	−	−	−	−	−	−	−	−	−
12th week after feeding...	2- 8-17	−	−	−	−	−	−	−	−	−
13th week after feeding...	2-15-17	−	−	−	−	−	−	−	−	−

(a) Born 11-5-16.

TABLE 10.

THE RESULT OF FEEDING NATURALLY INFECTED MILK TO A NEW BORN CALF.

Reaction of blood serum.	Date.	Heifer calf 102A. (a)								
		Agglutination.					Comp. Fix.			
		.1	.05	.025	.01	.005	.1	.04	.02	.005
Before feeding	12-21-16	–	–	–	–	–	–	–	–	–
1st week after feeding	12-28-16	No	test	made.						
2nd week after feeding	1- 6-17	+	p	–	–	–	+	+	–	–
3rd week after feeding	1-18-17	–	–	–	–	–	+	p	–	–
4th week after feeding	1-25-17	–	–	–	–	–	+	–	–	–
5th week after feeding	2- 1-17	–	–	–	–	–	p	–	–	–
6th week after feeding	2- 8-17	–	–	–	–	–	+	–	–	–
7th week after feeding	2-15-17	–	–	–	–	–	–	–	–	–
8th week after feeding	2-22-17	No	test	made						
9th week after feeding	3- 1-17	–	–	–	–	–	–	–	–	–
10th week after feeding	3- 8-17	–	–	–	–	–	–	–	–	–
11th week after feeding	3-15-17	–	–	–	–	–	–	–	–	–
12th week after feeding	3-22-17	–	–	–	–	–	–	–	–	–
13th week after feeding	3-29-17	–	–	–	–	–	–	–	–	–
14th week after feeding	4- 5-17	–	–	–	–	–	–	–	–	–
15th week after feeding	4-12-17	–	–	–	–	–	–	–	–	–
16th week after feeding	4-19-17	–	–	–	–	–	–	–	–	–

(a) Born 12-20-16.

TABLE 11.

THE RESULT OF FEEDING INFECTED MILK TO A NEW BORN CALF.

Reaction of blood serum.	Date.	Heifer calf 103A. (a)								
		Agglutination.					Comp. Fix.			
		.1	.05	.025	.01	.005	.1	.04	.02	.005
Before feeding	12-31-16	–	–	–	–	–	+	+	+	+
1st week after feeding	1- 8-17	–	–	–	–	–	+	+	+	+
2nd week after feeding	1-18-17	p	–	–	–	–	+	+	+	+
3rd week after feeding	1-25-17	–	–	–	–	–	+	+	+	+
4th week after feeding	2- 1-17	+	+	+	+	p	+	+	+	+
5th week after feeding	2- 8-17	+	+	+	+	–	+	+	+	–
6th week after feeding	2-15-17	+	+	+	+	–	+	+	+	–

(a) Born 12-31-16. Died of White Scours 2-19-17.

TABLE 12.

THE RESULT OF FEEDING INFECTED MILK TO A NEW BORN CALF.

Reaction of blood serum.	Date.	Bull calf 104A. (a)								
		Agglutination.					Comp.		Fix.	
		1	.05	.025	.01	.005	.1	.04	.02	.005
Before feeding...........	1-16-17	–	–	–	–	–	–	–	–	–
1st week after feeding....	1-23-17	–	–	–	–	–	–	–	–	–
2nd week after feeding...	1-30-17	–	–	–	–	–	–	–	–	–
3rd week after feeding...	2- 8-17	–	–	–	–	–	–	–	–	–
4th week after feeding...	2-15-17	–	–	–	–	–	–	–	–	–
5th week after feeding...	2-22-17	–	–	–	–	–	–	–	–	–
6th week after feeding...	3- 1-17	–	–	–	–	–	–	–	–	–
7th week after feeding...	3- 8-17	–	–	–	–	–	–	–	–	–
8th week after feeding...	3-15-17	–	–	–	–	–	–	–	–	–
9th week after feeding...	3-22-17	No	test	made						
10th week after feeding...	3-29-17	–	–	–	–	–	–	–	–	–
11th week after feeding...	4- 5-17	–	–	–	–	–	–	–	–	–
12th week after feeding...	4-12-17	–	–	–	–	–	–	–	–	–
13th week after feeding...	4-19-17	–	–	–	–	–	–	–	–	–

(a) Born 1-12-17.

TABLE 13.

THE RESULT OF FEEDING NON-INFECTED MILK PLUS A CULTURE OF BACTERIUM ABORTUS.

Reaction of blood serum.	Date.	Bull calf 1003A. (a)								
		Agglutination.					Comp.		Fix.	
		.1	.05	.025	.01	.005	.1	.04	.02	.005
Before feeding...........	2-21-16	–	–	–	–	–	–	–	–	–
Before feeding...........	3- 6-16	–	–	–	–	–	–	–	–	–
1st week after feeding....	3-13-16	–	–	–	–	–	+	+	+	p
2nd week after feeding...	3-20-16	–	–	–	–	–	+	+	+	p
3rd week after feeding...	3-27-16	–	–	–	–	–	+	+	+	p
4th week after feeding...	4- 3-16	–	–	–	–	–	+	+	+	–
5th week after feeding...	4-10-16	–	–	–	–	–	+	+	p	–
6th week after feeding...	4-17-16	–	–	–	–	–	+	+	–	–
7th week after feeding...	4-24-16	–	–	–	–	–	+	+	–	–
8th week after feeding...	5- 1-16	–	–	–	–	–	+	+	–	–
9th week after feeding...	5- 8-16	–	–	–	–	–	–	–	–	–
10th week after feeding...	5-15-16	–	–	–	–	–	+	–	–	–
11th week after feeding...	5-22-16	–	–	–	–	–	–	–	–	–
(b)12th week after feeding	5-29-16	–	–	–	–	–	–	–	–	–
15th week after feeding...	6-15-16	–	–	–	–	–	–	–	–	–
19th week after feeding...	7-10-16	–	–	–	–	–	–	–	–	–
25th week after feeding...	9-14-16	–	–	–	–	–	–	–	–	–
29th week after feeding...	10-15-16	–	–	–	–	–	–	–	–	–
33rd week after feeding...	12-15-16	–	–	–	–	–	–	–	–	–
37th week after feeding...	1-15-17	–	–	–	–	–	–	–	–	–

(a) Born 2-21-16.
(b) On this date the feeding of milk was discontinued.

TABLE 14.

THE RESULT OF FEEDING PASTEURIZED NATURALLY INFECTED MILK TO A NEW BORN CALF.

Reaction of blood serum.	Date.	Heifer calf 999A. (a)								
		Agglutination.					Comp. Fix.			
		.1	.05	.025	.01	.005	.1	.04	.02	.005
Before feeding...........	2- 3-16	–	–	–	–	–	–	–	–	–
1st week after feeding....	2-10-16	–	–	–	–	–	–	–	–	–
2nd week after feeding...	2-17-16	–	–	–	–	–	–	–	–	–
3rd week after feeding...	2-24-16	–	–	–	–	–	–	–	–	–
4th week after feeding...	3- 2-16	–	–	–	–	–	–	–	–	–
5th week after feeding...	3- 9-16	–	–	–	–	–	–	–	–	–
6th week after feeding...	3-16-16	–	–	–	–	–	–	–	–	–
7th week after feeding...	3-23-16	–	–	–	–	–	–	–	–	–
8th week after feeding...	3-30-16	–	–	–	–	–	–	–	–	–
9th week after feeding...	4- 6-16	–	–	–	–	–	–	–	–	–
10th week after feeding...	4-13-16	–	–	–	–	–	–	–	–	–
11th week after feeding...	4-20-16	–	–	–	–	–	–	–	–	–
12th week after feeding...	4-27-16	–	–	–	–	–	–	–	–	–
(b)13th week after feeding	5-11-16	–	–	–	–	–	–	–	–	–
17th week after feeding...	6- 3-16	–	–	–	–	–	–	–	–	–
19th week after feeding...	6-15-16	–	–	–	–	–	–	–	–	–
23rd week after feeding...	7-10-16	–	–	–	–	–	–	–	–	–
29th week after feeding...	9-14-16	–	–	–	–	–	–	–	–	–

(a) Born 2-3-16.
(b) On this date the feeding of milk was discontinued.

TABLE 15.

THE RESULT OF FEEDING NON-INFECTED MILK TO A NEW BORN CALF.

Reaction of blood serum.	Date.	Bull calf 1004A. (a)								
		Agglutination.					Comp. Fix.			
		.1	.05	.025	.01	.005	.1	.04	.02	.005
Before feeding...........	4-28-16	+	+	p	–	–	–	–	–	–
1st week after feeding....	5- 7-16	+	p	–	–	–	+	+	p	–
2nd week after feeding...	5-14-16	+	–	–	–	–	p	–	–	–
3rd week after feeding...	5-22-16	+	p	–	–	–	–	–	–	–
9th week after feeding...	6-29-16	–	–	–	–	–	–	–	–	–
12th week after feeding...	7-24-16	–	–	–	–	–	–	–	–	–

(a) Born 4-27-16.

TABLE 16.

THE RESULT OF FEEDING NON-INFECTED MILK TO A NEW BORN CALF.

Reaction of blood serum.	Date.	Heifer calf 1005A. (a)								
		Agglutination.					Comp. Fix.			
		.1	.05	.025	.01	.005	.1	.04	.02	.005
Before feeding	4-20-16	–	–	–	–	–	–	–	–	–
1st week after feeding	5- 3-16	–	–	–	–	–	–	–	–	–
2nd week after feeding	5-10-16	–	–	–	–	–	–	–	–	–
3rd week after feeding	5-17-16	–	–	–	–	–	–	–	–	–
9th week after feeding	6-29-16	–	–	–	–	–	–	–	–	–
12th week after feeding	7-24-16	–	–	–	–	–	–	–	–	–
21st week after feeding	10- 5-16	–	–	–	–	–	–	–	–	–

(a) Born 4-19-16.
This calf died the 10-8-16 of mechanical pneumonia. A small cyst was also found in the right ovary.

TABLE 17.

THE RESULT OF FEEDING NON-INFECTED MILK TO A NEW BORN CALF.

Reaction of blood serum.	Date.	Bull calf 1006A. (a)								
		Agglutination.					Comp. Fix.			
		.1	.05	.025	.01	.005	.1	.04	.02	.005
Before feeding	4-19-16	–	–	–	–	–	–	–	–	–
1st week after feeding	4-26-16	–	–	–	–	–	–	–	–	–
2nd week after feeding	5- 3-16	–	–	–	–	–	–	–	–	–
3rd week after feeding	5-10-16	–	–	–	–	–	–	–	–	–
10th week after feeding	6-29-16	–	–	–	–	–	–	–	–	–
13th week after feeding	7-10-16	–	–	–	–	–	–	–	–	–
24th week after feeding	10- 5-16	–	–	–	–	–	–	–	–	–

(a) Born 4-18-16.

TABLE 18.

THE RESULT OF FEEDING NON-INFECTED MILK TO A NEW BORN CALF.

Reaction of blood serum.	Date.	Bull calf 1007A. (a)								
		Agglutination.					Comp. Fix.			
		.1	.05	.025	.01	.005	.1	.04	.02	.005
2nd week after feeding...	4-21-16	–	–	–	–	–	–	–	–	–
3rd week after feeding...	4-29-16	–	–	–	–	–	–	–	–	–
4th week after feeding...	5- 6-16	–	–	–	–	–	–	–	–	–
5th week after feeding...	5-15-16	–	–	–	–	–	–	–	–	–
6th week after feeding...	5-22-16	–	–	–	–	–	–	–	–	–
14th week after feeding...	7-24-16	–	–	–	–	–	–	–	–	–
23rd week after feeding...	10- 5-16	–	–	–	–	–	–	–	–	–

(a) Born 4-2-16.

TABLE 19.

SHOWING SHOWING THE PRESENCE OF ANTIBODIES IN THE BLOOD OF A CALF WHICH WAS FIFTY-NINE DAYS OLD WHEN TESTED.

Reaction of blood serum.	Date.	Heifer calf 1008A. (a)								
		Agglutination.					Comp. Fix.			
		.1	.05	.025	.01	.005	.1	.04	.02	.005
(b) 8th week of feeding...	4-11-16	p	–	–	–	–	+	+	+	p
9th week of feeding......	4-26-16	–	–	–	–	–	+	+	–	–
10th week of feeding......	5- 3-16	+	+	p	–	–	+	+	+	–
11th week of feeding......	5-10-16	–	–	–	–	–	+	+	p	–
12th week of feeding......	5-17-16	–	–	–	–	–	+	p	–	–
27th week after feeding...	10- 5-16	–	–	–	–	–	–	–	–	–

(a) Born 2-20-16. (b) 1st blood test.

TABLE 20.

SHOWING THE PRESENCE OF ANTIBODIES IN THE BLOOD OF A CALF WHICH WAS SEVENTEEN DAYS OLD WHEN TESTED.

Reaction of blood serum.	Date.	Heifer calf 1009A. (a)								
		Agglutination.					Comp. Fix.			
		.1	.05	.025	.01	.005	1	.04	.02	.005
3rd week of feeding......	4-19-16	p	–	–	–	–	+	+	+	p
4th week of feeding......	4-26-16	–	–	–	–	–	+	+	p	–
5th week of feeding......	5- 2-16	p	–	–	–	–	+	+	+	–
6th week of feeding......	5- 9-16	–	–	–	–	–	+	–	–	–
7th week of feeding......	5-16-16	–	–	–	–	–	–	–	–	–
23rd week of feeding......	10-15-16	–	–	–	–	–	–	–	–	–

(a) Born 4-2-16.

FOREWORD.

TECHNICAL BULLETIN NO. 33.

The importance of bovine infectious abortion investigations is conceded by everyone interested in animal husbandry. Both practical men and scientists have been seeking assiduously but unsuccessfully for a solution of the problem. It has been suspected for some time that milk and the milk-secreting gland play a very important rôle in the dissemination of this disease amongst cattle. Naturally suspicion was aroused concerning infected milk as a food supply for human use. As a part of our attack on the project, "The Effect of Diseases in the Cow on the Milk," Mr. Cooledge has been working for several years on the most urgent phase of this subject and has presented in this paper some of the results of his investigations. We believe that these results throw a powerful light on the fundamentals of the whole subject, removing any cause for alarm in so far as the human problem is concerned and pointing out a safe and hopeful method of attack in so far as the live stock problem is concerned. This research is being continued by Mr. Cooledge and his associates.

WARD GILTNER.

A STUDY OF THE PRESENCE OF BACTERIUM ABORTUS (BANG) IN MILK.

BY L. H. COOLEDGE.

INTRODUCTION.

Part I.

Methods of studying the presence of *Bact. abortus* (Bang) in Milk.
- Introduction.
- Review of literature.
- Technic employed.
  - Complement-fixation test.
  - Agglutination test.
- Investigational work.
  - Comparing the *Bact. abortus* antibody content of the blood with that of the milk.
  - Comparing the antibody content of the milk from quarter to quarter.
  - Comparing the agglutination and complement-fixation reactions for *Bact. abortus* infection, using milk instead of blood serum.
  - Studying the agglutinins in milk after the introduction into the cow's udder of pure culture of *Bact. abortus*.
  - Studying the agglutination reaction of milk from cows with records of frequent abortions.
  - Studying the agglutination reaction of milk from cows that have never aborted.
  - Studying milk containing antibodies but not producing typical lesions in guinea-pigs.
  - Studying milk containing antibodies and producing typical lesion in guinea-pigs.

Part II.

A study of the effect of *Bact. abortus* upon man.
- Introduction.
- Review of literature.
- Technic employed.
- Investigational work.
  - A study of the presence of antibodies for *Bact. abortus* in the blood of adults.
  - A study of the antibody content of the blood of persons drinking a naturally infected milk.
  - A study of the antibody content of human blood serum while individuals are drinking a milk which does not contain antibodies but to which a pure culture of this organism is added.

A STUDY OF THE PRESENCE OF BACTERIUM ABORTUS (BANG) IN MILK.

INTRODUCTION.

While *Bact. abortus* (Bang), the organism that is generally thought to be the causative bacterium of the disease of cattle called contagious abortion was isolated by Bang in 1896, and his findings were later confirmed by other continental investigators, the organism was not isolated in England until 1909 and not until 1911 in the United States. In that year MacNeal and Kerr isolated from two cases of infectious abortion organisms which they regarded as identical with Bang's bacterium.

They describe this organism as follows: "The organism is a very small short rod, usually oval in shape, from 0.8 microns to 2.0 microns long by 0.7 microns wide, practically always single, rarely in short threads of two to four cells. It is not motile, and does not form spores. It stains with moderate rapidity with the ordinary aniline dyes, and is decolorized by Gram's method. The colonies on serum agar are raised, with smooth circular borders, appearing almost like drops of dew. They are transparent and very clear, with a bluish gray color by transmitted light. Under the microscope a few coarse granules may be seen near the center of the colony but the greater part of it appears very homogeneous and almost water clear. The appearance of the colony is really a very characteristic feature of the organism and enables one to distinguish readily the colony of the abortion bacillus from other colonies on the serum agar plates."

Another characteristic of this organism that is of value as a means of identification and that is largely responsible for the difficulty of isolation is its relation toward oxygen.

It has been shown that this organism when first isolated from diseased tissues will not grow under aerobic conditions, or under anaerobic conditions but requires an atmosphere partially depleted of oxygen. This atmospheric condition may be obtained artificially by growing the culture in a closed jar with a culture of *Bacillus subtilis,* one square centimeter of fresh growth of *B. subtilis* to each fifteen cubic centimeters of jar capacity giving the proper oxygen tension. In agar shakes of the newly isolated organism, growth will appear in a zone at a depth at which the proper amount of oxygen is present. This is usually about one cm. below the surface.

In 1912 Melvin reported that Mohler of the Pathological Division and Schroeder and Cotton of the Experiment Station of the Bureau of Animal Industry had isolated an organism from milk which was identical with the bacterium of infectious abortion.

Schroeder and Cotton consider the most remarkable thing about this organism to be its explusion from the bodies of apparently healthy cows with their milk. They prove this to be a fact by repeatedly demonstrating the presence of the organism in milk which had been collected with the greatest care against outside contamination. Cows which had previously been found to be infected were used. They also demonstrated

the presence of the organism in the front quarter of an infected animal after death.

Post-mortem examinations of cows reveal nothing to explain the persistent occurrence of the organism in the milk, except a few small areas of slight induration in the udder. The authors found *Bact. abortus* in 8 samples of market milk among 77 samples tested (over 11 per cent) and in the milk distributed by 6 of 31 dairies (over 19 per cent). Data available at the Experiment Station of the Bureau show that the bacterium of contagious abortion may be eliminated continuously for years with the milk of infected cows that no longer abort.

Mohler and Traum examined sera from 42 human beings. They obtained no positive results either by complement-fixation or agglutination tests. They also obtained tonsils from milk-consuming children at the various hospitals and inoculated guinea-pigs. Out of 56 tonsils and adenoids injected into guinea-pigs, tonsil No. 3 produced nodular areas in the liver, but cultures from this organ remained sterile. Tonsils from case No. 8 injected into 2 guinea-pigs produced in one of them after three months distinct lesions in the liver, spleen, and testicles, and *Bact. abortus* was obtained from the lesions.

Using 12 cows from a pure-bred Guernsey herd, two of which had aborted—the rest being chosen indiscriminately, Fabyan was unable to demonstrate the presence of *Bact. abortus* in the milk of any animals by cultural methods, but found the milk from the two cows that had aborted to have a much higher initial bacterial count. He also made guinea-pig inoculations using cream and a mixture of cream and sediment. He sums up his results as follows: "These tests show that *Bact. abortus* may be demonstrated by inoculation into guinea-pigs when cultural methods fail. They also show that *B. abortus* was present in a herd of cows kept under special precautions; that it was found in the milk of a cow which had aborted at the eighth, but not in one which had aborted in the third month, and that it was present in the milk of a cow which had calved eleven months previous and which had probably given infected milk continuously for nearly a year. It is furthermore evident that milk furnishes a medium in which *B. abortus* may multiply over long periods of time and remain as a constant source of infection for other cows."

Zwick and Krage demonstrated culturally the presence of the abortion bacillus in the milk of a cow that had aborted 14 days previously; then in an animal that had aborted 6 months previously and then in an animal 13 months after abortion. No abnormalties were discoverable by clinical examination, either in the udder or in the associated glands. The authors therefore conclude that either the bacillus is able to pass through the udder without producing lesions at all, or that the lesions are so slight as to be unrecognizable clinically. In order to determine whether the bacillus is responsible for lesions in the udder or changes in the milk and for how long injected bacilli may be excreted with milk, experiments were made in which bacilli were injected into the right halves of the udders of two goats. Examination of the milk showed that the abortion bacilli were excreted therein for a period of 3 to 5 months after the injection and that for about 8 weeks the number excreted hardly varied. Bacilli were never obtained from milk withdrawn from the left halves

of the udders. During the whole of the period covered by the experiment there was no visible alteration either in the udders or in the milk.

A second series of experiments was made in which two goats were inoculated subcutaneously with 10 c.c. of an emulsion of the bacillus in salt solution, and a third intravenously with the same quantity of an emulsion or about half the density.

The abortion bacillus was excreted in the milk of 2 of the goats (one infected subcutaneously and one intravenously) 24 hours after injection. The excretion of bacilli had not ceased 8 weeks after the commencement of the experiments. In the other goat inoculated subcutaneously the bacillus was not found in the milk 24 hours after inoculation, and it was found only on the 4 following days.

Cotton concludes from his investigations that: "1. The bacillus of infectious abortion may and in most cases does persist in the udders of cows that have aborted, for years and possibly for the balance of their lives; and during this time is eliminated more or less continuously with their milk."

"2. It may make its appearance in the milk months before abortion occurs, even before a conception that is terminated by an abortion."

"3. It may be eliminated for years from the udders of cows that have never aborted."

The investigators mentioned in the foregoing review have shown that *Bact. abortus* is often present in milk as it comes from the udders of apparently healthy cows. If this is accepted as true it is easy to see that the infection might be spread to young calves through the medium of the milk. The possibility of human infection must also be considered.

It now remains to develop more delicate and rapid methods for detecting the presence of this organism in milk, in order that a greater number of samples may be examined, and that conclusions as to the significance of the presence of this bacterium in milk may be more rapidly obtained.

With these objects in view our investigations were directed along the following lines:

Part I. Methods of studying the presence of *Bact. abortus* in milk.
Part II. A study of the effect of *Bact. abortus* upon man.
Part III. Facts disclosed by a study of the presence of *Bact. abortus* in milk by means of the Agglutination Test.

Part I.

Methods of Studying the Presence of *Bacterium abortus* (Bang) in Milk.

As mentioned in the introduction to this paper the isolation of *Bact. abortus* from infected material is very difficult owing to the fact that this organism when first isolated is neither aerobic nor anaerobic but requires an atmosphere for growth which is partially depleted of oxygen. This proper oxygen pressure has been obtained by investigators in several ways. Briefly these are as follows:

In the cultural method devised by Nowak, the proper oxygen tension is obtained by growing agar streaks of the suspected material in a closed jar with *Bacillus subtilis,* having one sq. cm. of culture surface for each 15 c.c. of jar capacity. The small colonies usually will have appeared

at the end of four days. If these colonies are picked off with a platinum needle and agar shakes made it will be found that a zone of growth will appear at a depth below the surface at which the proper amount of oxygen is present. This is usually about 1 cm. with a second faint zone sometimes appearing at a greater depth. While the writer has isolated *Bact. abortus* from milk sediment by this method, it is too tedious a process to apply to any number of samples. Plates are likely to be overgrown with colonies of fast-growing organisms, and the method has the further disadvantage of requiring several weeks to isolate and identify the cultures.

Alkaline pyrogallol has been used by several investigators to obtain the desired amount of oxygen in a closed jar, but without any great success.

Others claim that if an inoculated agar slant is sealed and incubated there will be a period at which the proper amount of oxygen is present due to partial absorption of oxygen by the agar.

Miss Evans succeeded in isolating from milk, organisms which she believes to be *Bact. abortus*, by plating on ordinary lactose agar to which 10 per cent of sterile blood serum was added just before plating. After incubating for four days, the colonies which developed were transferred to nutrient broth containing 1 per cent of glycerine and to tubes of whole milk containing litmus.

Dr. Giltner has devised an H tube which has been found of great value in growing newly isolated cultures of *Bact. abortus*. One arm of the tube contains ordinary agar upon which *B. subtilis* is grown. The other arm of the tube contains a serum agar slant upon which the culture of *Bact. abortus* is inoculated. The cotton plugs are pushed down into the tubes and tight rubber stoppers inserted. This method is more convenient than the ordinary jar method as it is possible to open one tube without disturbing others as in the jar method. It has the further advantage that the culture can easily be watched and handled.

Another method of study, the inoculation of guinea-pigs with the milk, while more reliable, is far from satisfactory, owing to the fact that it takes 8 to 10 weeks for the lesions to develop, and it is probable that the organisms must be present in large numbers to cause the characteristic lesions with the 5 c.c. of milk used for inoculation.

In the investigation of the effect on milk of the diseases of the cow, with special reference to infectious abortion, it was found desirable to examine a large number of samples to determine whether or not *Bact. abortus* was being passed with the milk. The cultural and animal inoculation methods were the only ones found available for this work. As these methods are unsatisfactory because of the length of time required, it has been found necessary to develop new technic in order to study a large number of samples. Knowing that this organism is sometimes present in considerable numbers in milk as it comes from the cow's udder, it was thought that this might indicate an infection of the udder and a consequent local production of antibodies. Zinsser says in this connection, that "it is more than probable that antibodies may be formed anywhere in the body and that the locality of their production is largely dependent upon the locality in which the antigen is concentrated."

This led the writer to believe that the agglutination and complement

fixation tests might be of value in locating *Bact. abortus* infected udders and in studying the presence of this organism in milk. Tests were made using milk and milk serum instead of the usual method of using blood serum. *Bact. abortus* was used as antigen.

TECHNIC EMPLOYED.

Complement-Fixation Test.—A modification of the complement-fixation test as used by Surface was employed in the work. These modifications were made by I. F. Huddleson. Antigen was prepared for the test by growing a culture of *Bact. abortus* upon ordinary agar, for 48 hours. The growth was then washed off with a solution containing 0.9 percent sodium chloride and 0.5 per cent phenol. The suspension was filtered through a coarse filter paper and standardized so that the turbidity compared with tube 5 of McFarland's nephelometer. The suspension was then shaken for five hours to obtain homogeneity. When placed in a dark bottle and stored at 5° C. the titer of this antigen was found to remain constant for many months. No modifications were made in the preparation of complement, hemolysin and positive serum or in their titration. The outline shown in the table below was followed for these tests.

OUTLINE FOLLOWED FOR COMPLEMENT FIXATION TEST.

Tube No.	Serum tested.	Antigen	Complement (1-4) dil.	NaCl .9%	Incubate in water bath 30 min. at 37°C.	Hemolysin 1%	Sheep erythrocytes 2.5%	Incubate in water bath 45 min. at 37°C	Result
		(b)	(b)			(b)			
1.....	.1cc.	2 x t	2 x t	1.5cc.		2 x t	.5cc.		No hemolysis.
2.....	.04cc.	2 x t	2 x t	1.5cc.		2 x t	.5cc.		No hemolysis.
3.....	.02cc.	2 x t	2 x t	1.5cc.		2 x t	.5cc.		No hemolysis.
4.....	.005cc.	2 x t	2 x t	1.5cc.		2 x t	.5cc.		Partial hemolysis.
5 (a)..	.1cc.	....	2 x t	1.5cc.		2 x t	.5cc.		Hemolysis.
6.....	.1cc.	....	2 x t	1.5cc.		2 x t	.5cc.		Hemolysis.

(a) Add sheep cells during first incubation to determine presence of natural hemolysin.
(b) Two times titer found on titration.

Rennet milk serum was used in the following quantities: 0.1, 0.04, 0.02, and 0.005 c.c.

Agglutination Test.—Antigen was prepared for the agglutination test in the same way that it was prepared for the complement-fixation test except that it was not shaken and was standardized so that the turbidity compared with tube 1.5 of McFarland's nephelometer. Four c.c. of this bacterial suspension was placed in each of the small test tubes and the following quantities of milk added: 0.1, 0.05, 0.025, 0.01, and 0.005 c.c. In this way approximate dilutions of 1 to 50, 1 to 100, 1 to 200, 1 to 500, and 1 to 1,000 were obtained. It was found that turbidity due to the whole milk added did not interfere with the reading of the reaction. When a dilution lower than 1 to 50 was made, rennet milk serum was used.

INVESTIGATIONAL WORK.

It has been proposed by some investigators of infectious abortion that milk be used as a means of diagnosis. As it is often much easier

to obtain a sample of milk than to obtain a sample of blood, provided results are comparable, this method would be of great value.

Melvin has stated that the agglutinating power of milk for *Bact. abortus* is approximately half as strong as that of the blood serum.

A comparison of the *Bact. abortus* antibody content of the blood with that of the milk is shown in Table I.

TABLE I.—COMPARING THE *BACT. ABORTUS* ANTIBODY CONTENT OF THE BLOOD WITH THAT OF THE MILK.

Cow No.	Reaction of blood.									Reaction of milk.								
	Agglutination test.					Comp. F. test.				Agglutination test.					Comp. F. test.			
	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	.1	.04	.02	.005	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	.1	.04	.02	.005
124	−	−	−	−	−	−	−	−	−	p	−	−	−	−	+	+	+	p
85	p	−	−	−	−	+	+	+	+	+	+	+	p	−	+	+	−	−
97	−	−	−	−	−	−	−	−	−	p	−	−	−	−	+	+	+	−
77	−	−	−	−	−	+	+	+	+	+	+	+	−	−	+	+	+	−
91	+	+	+	+	−	+	+	+	+	+	+	+	−	−	−	−	−	−
59 } A.1	−	−	−	−	−	−	−	−	−	+	+	+	p	−	+	−	−	−*

*Milk from L. R. quarter. The milk from other quarters negative.

In this table it is seen that there is apparently no constant relation between the *Bact. abortus* antibody content of the blood and of the milk. In some instances the blood reacts while the milk is negative and again in other instances the milk will react when the blood is negative. The fact that there seems to be no connection between the antibodies in the blood stream and those in the milk leads the writer to believe that the *Bact. abortus* antibodies in the milk are not to be accounted for by the usual statement that they come from the blood stream. Attempts are made in future experiments to explain the presence of these antibodies in the milk.

In Table II it is shown that the *Bact. abortus* antibody content of milk may vary from quarter to quarter.

TABLE II.—SHOWING THAT THE *BACT. ABORTUS* ANTIBODY CONTENT OF MILK MAY VARY FROM QUARTER TO QUARTER.

Cow No.	Quarter.	Agglutination test.					Complement F. test.			
		0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	.1	.04	.02	.005
113......	R.R........	p	−	−	−	−	−	−	−	−
	R.F........	+	−	−	−	−	p	−	−	−
	L.R........	+	+	+	−	−	+	+	+	−
	L.F........	p	−	−	−	−	p	−	−	−
71......	R.R........	−	−	−	−	−	−	−	−	−
	R.F........	−	−	−	−	−	−	−	−	−
	L.R........	+	+	+	p	−	+	−	−	−
	L.F........	p	−	−	−	−	−	−	−	−
91......	R.R........	+	p	−	−	−	−	−	−	−
	R.F........	+	+	+	−	−	+	+	−	−
	L.R........	+	+	+	−	−	+	+	−	−
	L.F........	+	+	+	+	+	+	+	−	−

If the antibodies for *Bact. abortus* found in milk originate in the blood stream it would seem reasonable to expect their presence in the different quarters of the udder in about the same concentration. That this is not the case is seen in the above table. Here we find that one or more quarters may contain antibodies while the others are negative. The only way to account for this distribution of antibodies, it seems to the writer, is to assume that there might be an invasion of one or more quarters of the udder by *Bact. abortus* and a consequent local production of antibodies. If this is found to be the case these tests might prove to be of great value in studying the presence of *Bact. abortus* in milk.

As has been stated previously, the only means we now have of studying the presence of *Bact. abortus* in milk are far from satisfactory in that they are not delicate and require such an expenditure of time that it is possible to study only a limited number of samples. By testing for *Bact. abortus* antibodies, if these prove to indicate infected quarters of a cow's udder, it would be possible to examine many samples of milk where we now examine one.

The agglutination test is simple and in blood serum tests gives approximately the same results as the complement fixation test. To determine whether or not the complement fixation test might be omitted a comparison was made of the agglutination and complement fixation reactions testing milk instead of blood serum. This is shown in Table III.

TABLE III.—A COMPARISON OF THE AGGLUTINATION AND COMPLEMENT FIXATION REACTIONS FOR *BACT. ABORTUS* INFECTION TESTING MILK INSTEAD OF BLOOD SERUM.

Sample	Agglutination test					Comp. F. test				Sample	Agglutination test					Comp. F. test			
	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	.1	.04	.02	.005		0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	.1	.04	.02	.005
1	p	—	—	—	—	—	—	—	—	16	+	+	+	—	—	—	—	—	—
2	+	—	—	—	—	p	—	—	—	17	+	+	+	—	—	p	—	—	—
3	+	+	+	—	—	+	+	+	—	18	+	+	+	p	—	+	+	—	—
4	p	—	—	—	—	p	—	—	—	19	+	+	+	p	—	p	p	p	p
5	+	+	+	p	—	+	+	+	—	20	+	+	p	—	—	+	p	—	—
6	+	+	+	p	—	+	+	+	—	21	+	+	+	—	—	—	—	—	—
7	+	+	+	p	—	+	+	+	—	22	+	+	+	—	—	+	+	—	—
8	+	+	p	—	—	+	+	p	—	23	+	+	+	—	—	+	+	p	—
9	+	p	—	—	—	—	—	—	—	24	+	+	+	p	—	+	+	p	—
10	+	p	—	—	—	—	—	—	—	25	+	+	+	p	—	+	+	+	—
11	+	+	+	—	—	+	+	—	—	26	+	—	—	—	—	p	—	—	—
12	+	+	+	—	—	+	+	—	—	27	+	+	+	p	—	+	—	—	—
13	+	+	+	+	+	+	+	—	—	28	+	+	+	p	—	p	p	—	—
14	+	+	+	—	—	—	—	—	—	29	p	—	—	—	—	+	+	+	p
15	+	+	+	—	—	—	—	—	—	30	p	—	—	—	—	+	+	+	—

In this table it is seen that the agglutination test reveals a higher percentage of positive samples than does the complement fixation test and is apparently more delicate. For these reasons the complement fixation test is omitted in some of the following experiments.

For the experiment given in Table IV, a cow was selected whose milk had given a negative agglutination reaction since first tested, October

10, 1914, using *Bact. abortus* as antigen. Thirty-five c.c. of a 48-hour broth culture of *Bact. abortus* were introduced into the right rear quarter after it had been milked dry. As shown in the table, the agglutinins had appeared in the right rear quarter the following day and soon spread to the other quarters. This spreading was probably brought about by the organism being carried from quarter to quarter upon the hands during milking. After the cow freshened the reaction was seen to die out gradually.

TABLE IV.—SHOWING THE APPEARANCE IN MILK OF AGGLUTININS FOR BACTERIUM ABORTUS AFTER THE INTRODUCTION INTO THE COW'S UDDER OF A PURE CULTURE OF *BACT. ABORTUS*. (a)

(Agglutination reaction at middle of milking, when various quantities of milk were added to test tubes containing bacterial suspension.)

Date	Right rear quarter					Right front quarter					Left rear quarter					Left front quarter				
	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.
1914																				
Oct. 10....	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
1915																				
Feb. 8...	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Feb. 15...	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Feb. 24...	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Feb. 25...	(b)	(b)	(b)	(b)	(b)															
Feb. 26...	+	p	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Feb. 27...	p	p	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Mar. 1...	+	+	+	−	−	+	p	−	−	−	+	p	−	−	−	+	p	−	−	−
Mar. 2...	+	+	−	−	−	+	p	p	−	−	+	+	+	p	−	+	p	p	−	−
Mar. 5...	+	+	−	−	−	+	+	p	−	−	+	+	+	p	−	+	+	p	−	−
Mar. 8...	+	+	+	−	−	+	+	+	p	−	+	+	+	−	−	+	+	+	−	−
Mar. 9...	(c)	(c)	(c)	(c)	(c)															
Mar. 10...	+	p	−	−	−	+	+	−	−	−	+	p	−	−	−	+	p	−	−	−
Mar. 11...	+	−	−	−	−	+	−	−	−	−	+	−	−	−	−	+	−	−	−	−
Apr. 17...	+	+	p	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
May 26...	+	p	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
June 4...	p	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
July 28...	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Aug. 21...	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Sept. 13...	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−

(a) In all cases, unless otherwise stated, the milk was taken a little before what was estimated to be the middle of the milking.

(b) 35 c.c. of a 48-hour broth culture of Bact. abortus introduced into right rear quarter.

(c) Cow calved. Bull calf died on Mar. 13, 1915, owing to undigested curd. Reaction of blood of calf; —agglutination; +complement-fixation test.

In Table V we have the record of another cow treated in much the same way as the cow in Table IV, except that a smaller amount of *Bact. abortus* culture was introduced into the right front quarter where it produced the agglutination reaction indicating infection. The infection, however, had not spread to the other quarters when last tested, though it remained strong in the right front quarter. Cultures used in this test may have lost some of their virulence having been grown under laboratory conditions for over a year.

TABLE V.—SHOWING THE APPEARANCE OF *BACT. ABORTUS* AGGLUTININS IN A COW'S UDDER AFTER THE INTRODUCTION OF A CULTURE OF *BACT. ABORTUS*.

(Agglutination reaction when various quantities of fore milk were added to the test tubes containing bacterial suspension.)

Date	Right rear quarter					Right front quarter					Left rear quarter					Left front quarter				
	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.
10-12-16..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10-16-16..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10-16-16..	....	....	.....	....	.....	a	a	a	a	a										
10-17-16..	p	—	—	—	—	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—
10-19-16..	p	—	—	—	—	+	p	p	—	—	—	—	—	—	—	—	—	—	—	—
10-23-16..	p	p	—	—	—	+	+	+	—	—	—	—	—	—	—	—	—	—	—	—
10-30-16..	—	—	—	—	—	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—
11- 8-16..	—	—	—	—	—	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—
11-10-16..	—	—	—	—	—	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—
11-14-16..	—	—	—	—	—	+	+	+	—	—	—	—	—	—	—	—	—	—	—	—
11-22-16..	—	—	—	—	—	+	+	+	+	—	—	—	—	—	—	—	—	—	—	—

(a) 5 c.c. of a 48 hour broth culture of *Bact. abortus*, a mixture of strains A, I and III were inoculated into the milk cistern of the right front quarter immediately after milking.

It seems that the appearance of antibodies in the milk soon after the introduction of a pure culture into the milk cistern would be sufficient grounds for concluding that, conversely, the appearance of agglutinins in the milk would indicate a *Bact. abortus* infection. This might be a local infection of the udder or it might be due to an infection in which the antibodies present in the blood stream appear in the milk by diffusion from the blood.

That the appearance of *Bact. abortus* antibodies in the milk indicates an infection of the cow's udder and not diffusion of the antibodies from the blood stream is indicated in Table I where there is apparently no connection between the antibodies of the blood stream and those of the milk. In some instances milk having a negative or weak antibody content was taken from cows having a strong blood reaction and vice versa.

Another fact which shows that the antibodies present in the milk do not come from the blood stream is brought out in Table II where it is found that the antibody content of the milk may vary from quarter to quarter. If the antibodies had their source in the blood stream the milk from each quarter should be expected to have about the same concentration of antibodies.

Table VI gives the history of milk from a cow with a record of frequent abortions. As shown in the table, the isolation of *Bact. abortus* from the milk and the results of guinea-pig inoculation prove the presence of this bacterium, as indicated by agglutination reactions.

TABLE VI.—HISTORY OF MILK FROM A COW WITH A RECORD OF FREQUENT ABORTIONS. (a)

(Agglutination reaction at middle of milking, when various quantities of milk were added to test tubes containing bacterial suspension.)

Date	Right rear quarter					Right front quarter					Left rear quarter					Left front quarter				
	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.
1914																				
Jan. 10(b).	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Apr. 30...	+	+	+	−	−	+	+	p	−	−	+	+	+	p	−	+	+	+	+	−
May 5...	+	+	+	−	−	+	+	p	−	−	+	+	−	−	−	+	+	+	−	−
June 20...	+	+	+	p	−	+	+	+	−	−	+	+	+	p	−	+	+	+	p	−
July 11...	+	−	−	−	−	+	p	−	−	−	+	+	+	p	−	+	p	−	−	−
July 12(c).	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 10...	+	+	−	−	−	+	+	+	p	−	+	+	+	p	−	+	+	+	p	−
Aug. 28...	+	+	−	−	−	+	−	−	−	−	+	+	−	−	−	+	+	−	−	−
Oct. 10...	+	+	−	−	−	+	+	−	−	−	+	+	+	−	−	+	+	+	−	−
Oct. 31...	+	+	p	−	−	+	+	+	−	−	+	+	+	p	−	+	+	+	−	−
Nov. 19(d).	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

(a) Known abortions: Dec., 1909; Jan., 1914. Jan., 1911, last living normal calf. Other records of abortions lost.
(b) Isolated a pure culture of Bact. abortus direct from milk.
(c) Guinea pigs inoculated intra-abdominally with milk from each quarter had typical *Bact. abortus* lesions when autopsies were performed eight weeks later.
(d) Died; impaction of stomach. No lesions or abnormal conditions found in udder.

In Tables VII and VIII the records of milk from two additional cows are given. Here again we have positive agglutinations coupled with abortions and milk shown to contain *Bact. abortus* by guinea-pig inoculation.

TABLE VII.—HISTORY OF MILK FROM A COW WITH A RECORD OF FREQUENT ABORTIONS.

(Agglutination reaction at middle of milking, when various quantities of milk were added to test tubes containing bacterial suspension.)

Date	Right rear quarter					Right front quarter					Left rear quarter					Left front quarter				
	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.
1914																				
July 20...	+	P	−	−	−	+	+	P	−	−	+	+	−	−	−	+	P	−	−	−
Aug. 4(a)..	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 10...	+	+	−	−	−	+	+	−	−	−	+	+	+	−	−	+	+	−	−	−
Aug. 24...	+	+	+	−	−	+	+	+	−	−	+	+	−	−	−	+	+	−	−	−
Oct. 1...	+	+	+	−	−	+	+	P	−	−	+	+	+	−	−	+	+	+	−	−
Nov. 27(b).	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Nov. 27...	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Dec. 2...	+	+	+	−	−	+	+	+	−	−	+	+	+	−	−	+	+	+	−	−
1915																				
Jan. 15...	+	+	P	−	−	+	P	−	−	−	+	P	−	−	−	+	−	−	−	−
Mar. 25...	P	P	−	−	−	P	P	−	−	−	P	P	−	−	−	P	P	−	−	−
June 8...	P	P	−	−	−	P	P	−	−	−	P	−	−	−	−	P	−	−	−	−
June 30(c).	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Sept. 10(d)	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Oct. 10...	+	+	P	−	−	+	+	P	−	−	+	+	P	−	−	+	+	P	−	−
Nov. 4...	+	P	−	−	−	+	P	−	−	−	+	+	P	−	−	+	+	P	−	−

(a) Guinea pigs inoculated intra-abdominally with milk from each quarter had typical *Bact. abortus* lesions when autopsies were performed 10 weeks later.
(b) Aborted a 7-month fetus.
(c) Right rear quarter, positive guinea-pig inoculation. Right front quarter lost, and left rear and left front quarters negative.
(d) Aborted a 7-month fetus.

TABLE VIII.—HISTORY OF MILK FROM A COW THAT HAS ABORTED.

(Agglutination reaction at middle of milking, when various quantities of milk were added to test tubes containing bacterial suspension.)

Date	Right rear quarter					Right front quarter					Left rear quarter					Left front quarter				
	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.
1915																				
July 1(a).	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Oct. 8...	+	+	+	+	–	+	+	+	–	–	–	–	–	–	–	+	+	+	–	–
Oct. 27(b)	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Nov. 4...	+	+	+	–	–	+	+	–	–	–	+	P	–	–	–	+	P	–	–	–
1916																				
Jan. 19...	+	+	+	+	P	+	+	+	–	–	+	P	–	–	–	+	+	+	–	–
Mar. 14...	+	+	+	+	+	+	+	+	P	–	+	+	P	–	–	+	+	+	P	–

(a) Guinea pigs inoculated intra-abdominally with milk from each quarter had typical *Bact. abortus* lesions and blood reactions.
(b) Aborted an 8 months foetus.

In Table IX is given the record of milk from a cow that has never aborted. On June 16, 1915, agglutinins had appeared in all but the left front quarter. Guinea-pig inoculations made on June 30 were positive for infectious abortion in all but the left front quarter. On October 16, 1915, the reaction had spread to the left front quarter.

TABLE IX.—HISTORY OF MILK FROM A COW THAT HAS NEVER ABORTED.

(Agglutination reaction at middle of milking, when various quantities of milk were added to test tubes containing bacterial suspension.)

Date	Right rear quarter					Right front quarter					Left rear quarter					Left front quarter				
	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.
1915																				
Apr. 9...	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
June 16...	+	P	–	–	–	P	P	–	–	–	+	P	–	–	–	–	–	–	–	–
(a)June 30.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Oct. 16...	+	+	P	–	–	+	+	+	–	–	+	+	–	–	–	+	+	+	+	–
1916																				
Jan. 19...	+	+	+	+	–	+	+	+	–	–	+	+	+	+	+	+	+	+	–	–

(a) Guinea pigs inoculated intra-abdominally with milk from each quarter had typical *Bact. abortus* lesions and blood reactions, with exception of left front quarter, which was normal.

When the antibodies for *Bact. abortus* were found present in the milk, especially in great concentration this organism was usually found also. That the organism was not always found when the antibodies were found the writer thinks may be due to the fact that the infection was disappearing or was so slight that there were not enough organisms present to cause the disease in guinea pigs with the 5 c.c. of milk used for inoculation.

In Table X will be found the record of milk that had a positive antibody content but in which *Bact. abortus* was not demonstrated by guinea pig inoculation.

TABLE X.—HISTORY OF MILK CONTAINING *BACT. ABORTUS* ANTIBODIES BUT GIVING NEGATIVE GUINEA PIG INOCULATIONS.

(Agglutination reaction at middle of milking, when various quantities of milk were added to test tube containing bacterial suspension.)

Date	Right rear quarter					Right front quarter					Left rear quarter					Left front quarter				
	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 c.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.
Cow 87 1914																				
June 9...	+	+	+	+	+	+	+	+	P	−	....	....	....	....	....	+	+	+	+	(a) −
June 11...	+	+	+	+	+	+	+	+	−	−	....	....	....	....	....	+	+	+	P	(b) −
June 13...	+	+	P	−	−	+	P	−	−	−	....	....	....	....	....	+	P	−	−	−
June 30...	+	+	+	−	−	−	−	−	−	−	....	....	....	....	....	−	−	−	−	−
July 11...	−	−	−	−	−	−	−	−	−	−	....	....	....	....	....	−	−	−	−	−
Aug. 4...	(A)	(A)	(A)	(A)	(A)															
Aug. 10...	+	+	−	−	−	−	−	−	−	−	....	....	....	....	....	−	−	−	−	−
Oct. 1...	+	+	+	P	−	P	P	−	−	−	....	....	....	....	....	P	−	−	−	−
Cow 107 1914																				
May 15...	−	−	−	−	−	−	−	−	−	−	+	+	+	+	−	+	+	+	P	−
May 22...	P	−	−	−	−	−	−	−	−	−	+	+	+	−	−	+	+	+	P	−
June 12...	+	+	P	−	−	P	−	−	−	−	+	+	+	+	−	+	+	+	P	−
July 11...	−	−	−	−	−	+	P	−	−	−	+	−	−	−	−	+	P	−	−	−
July 12...	(A)	(A)	(A)	(A)	(A)															
July 22...	+	+	+	P	P	+	+	+	+	P	+	+	+	+	P	+	+	+	+	+
Aug. 10...	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Aug. 28...	−	−	−	−	−	+	+	−	−	−	−	−	−	−	−	−	−	−	−	+
Oct. 1...	+	+	P	−	−	+	+	P	−	−	+	+	P	−	−	+	+	+	P	P
Dec. 18...	−	−	−	−	−	−	−	−	−	−	+	+	+	−	−	+	+	+	−	−
1915																				
Jan. 29...	+	+	+	+	−	+	P	−	−	−	+	+	+	−	−	+	+	+	P	−
June 10...	+	+	+	+	+	+	P	−	−	−	+	+	+	−	−	+	+	+	P	−
Oct. 22...	+	+	+	+	−	+	+	+	P	−	+	+	+	P	−	+	+	+	+	−
Oct. 27...	(A)	(A)	(A)	(A)	(A)															
Nov. 4...	+	+	+	+	+	+	+	+	−	−	+	+	+	+	P	+	+	+	+	+
Cow 111 1915																				
Oct. 8...	....	....	....	....	....	−	−	−	−	+	−	−	−	−	−	−	−	−	−	(c) −
Oct. 27...	(A)	(A)	(A)	(A)	(A)															
Nov. 4...	....	....	....	....	....	P	−	−	−	−	+	−	−	−	−	−	−	−	−	−
1916																				
Mar. 30...	P	−	−	−	−	P	−	−	−	−	+	+	+	−	−	+	+	+	−	−
May 16...	+	+	−	−	−	+	+	−	−	−	+	−	−	−	−	+	−	−	−	−
Cow 113 1914																				
May 14...	+	+	P	−	−	−	−	−	−	−	+	+	P	−	−	−	−	−	−	−
May 22...	+	+	−	−	−	−	−	−	−	−	+	+	−	−	−	P	−	−	−	−
June 12...	+	+	−	−	−	−	−	−	−	−	+	+	P	−	−	−	−	−	−	−
June 24...	(A)	(A)	(A)	(A)	(A)															
June 29...	+	+	−	−	−	+	+	P	−	−	+	+	−	−	−	+	+	−	−	−
July 3...	+	P	−	−	−	+	P	−	−	−	+	+	P	−	−	+	P	−	−	−
Aug. 10...	−	−	−	−	−	+	+	−	−	−	−	−	−	−	−	−	−	−	−	−
Aug. 24...	+	+	+	−	−	+	+	−	−	−	+	+	−	−	−	+	+	−	−	−
Oct. 1...	+	P	−	−	−	+	+	−	−	−	+	P	−	−	−	+	−	−	−	−
Oct. 27...	+	−	−	−	−	+	−	−	−	−	+	−	−	−	−	+	−	−	−	−
Nov. 16...	+	P	−	−	−	+	P	−	−	−	+	−	−	−	−	+	P	−	−	−

TABLE X.—*Concluded.*

Date	Right rear quarter					Right front quarter					Left rear quarter					Left front quarter				
	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.	0.1 cc.	0.05 cc.	0.025 cc.	0.01 cc.	0.005 cc.
1915																				
Apr. 6...	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
June 30...	(A)	(A)	(A)	(A)	(A)															
Oct. 16...	–	–	–	–	–	–	–	–	–	–	+	+	+	–	–	–	–	–	–	–
Oct. 27...	(A)	(A)	(A)	(A)	(A)															
Nov. 4...	–	–	–	–	–	+	P	–	–	–	+	+	P	–	–	P	–	–	–	–
1916																				
May 16...	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–

(A)5 c. c. of milk from each quarter inoculated into guinea pigs with negative results.
(a) Colostrum.
(b) L. R. Dry.
(c) R. R. Dry.

The writer is satisfied that these are instances of *Bact. abortus* infection though perhaps in a rather inactive stage. With a view toward finding a means of selecting the cows having actively infected udders and consequently giving milk containing enormous numbers of *Bact. abortus,* a comparative study was made of the cellular and antibody content of the fore milk and the strippings. In Table XI will be found such a study of milk capable of producing typical *Bact. abortus* lesions in guinea pigs.

TABLE XI.—A COMPARISON OF THE ANTIBODY AND CELLULAR CONTENT OF THE FORE MILK AND STRIPPINGS OF REACTING MILK CAPABLE OF CAUSING TYPICAL INFECTIOUS ABORTION LESIONS IN GUINEA PIGS.

(Agglutination reaction when various quantities of milk were added to test tubes containing bacterial suspension.)

	Right Rear Quarter.						Right Front Quarter.						Left Rear Quarter.						Left Front Quarter.					
	Agglutination.					Cells per c. c.	Agglutination.					Cells per c. c.	Agglutination.					Cells per c. c.	Agglutination.					Cells per c. c.
	0.1 c. c.	0.05 c. c.	0.025 c. c.	0.01 c. c.	0.005 c. c.		0.1 c. c.	0.05 c. c.	0.025 c. c.	0.01 c. c	0.005 c. c.		0.1 c. c.	0.05 c. c.	0.025 c. c.	0.01 c. c.	0.005 c. c.		0.1 c. c.	0.05 c. c.	0.025 c. c.	0.01 c. c.	0.005 c. c.	
Cow No. 91:																								
Fore Milk.....	+	+	+	P	—	400,000	+	+	+	+	—	1,200,000	+	+	+	P	P	900,000	+	+	+	—	—	4,500,000
Strippings.....	+	+	+	P	—	3,600,000	+	+	+	P	—	1,200,000	+	+	+	P	—	900,000	+	+	+	P	—	9,000,000
						A.						A.						A.						A.
Cow No. 81:																								
Fore Milk.....	+	+	+	+	+	10,000,000	+	+	+	+	P	1,500,000	+	+	+	—	—	5,700,000	+	+	+	+	—	480,000
Strippings.....	+	+	+	+	—	7,000,000	+	+	+	+	P	6,000,000	+	+	+	—	—	3,600,000	+	+	+	P	—	7,000,000
						A.						A.						A.						A.
Cow No. 77:																								
Fore Milk.....	+	+	+	P	—	30,000	+	+	+	P	—	3,000,000	+	+	+	P	P	2,000,000	+	P	—	—	—	60,000
Strippings.....	+	+	+	+	—	210,000	+	+	+	—	—	5,000,000	+	+	+	P	—	23,000,000	+	—	—	—	—	2,700,000
						A.						A.						A.						A.
Cow No. 61:																								
Fore Milk.....	+	+	+	P	—	30,000	+	+	+	P	—	30,000	+	+	+	P	—	30,000	—	—	—	—	—	30,000
Strippings.....	+	+	+	P	—	360,000	+	+	+	P	—	210,000	+	+	+	P	P	960,000	—	—	—	—	—	30,000
						B.						B.						B.						B.
Cow No. 996:																								
Fore Milk.....	P	—	—	—	—	30,000	+	P	P	—	—	1,900,000	—	—	—	—	—	30,000	—	—	—	—	—	30,000
Strippings.....	P	P	—	—	—	450,000	+	+	+	P	—	18,000,000	—	—	—	—	—	90,000	—	—	—	—	—	210,000
						C.						C.						C.						C.

A. Guinea pigs inoculated with 5 c.c. of milk from each quarter developed typical *Bact abortus* lesions and blood reactions.

B. Guinea pigs inoculated with 5 c.c. of milk from each quarter developed typical *Bact. abortus* lesions and blood reactions. Exception, guinea pig inoculated from L. F. Quarter which did not develop lesions.

C. Right front quarter of this cow's udder inoculated with a pure culture of *Bact. abortus* 3 days previous to this test. See Table V.

Here we see that in nearly every case the strippings have as high or a higher antibody and cellular content than does the fore milk. It seems to the writer that this is the condition which might be expected in case of an active *Bact. abortus* infection. The more vigorous manipulation of the udder during the stripping process tends to force the antibodies and cells of infected udder tissue into the milk stream. This results in the strippings having a high antibody and cellular content. In cow 996 of this table the udder was artificially infected with a culture of *Bact. abortus* and it will be noticed that the comparative strength of the reactions in the fore milk and strippings is the same as in the other instances in which the infection appeared naturally.

In Table XII will be found a comparison of the antibody and cellular content of fore milk and strippings of reacting milk not capable of causing typical *Bact. abortus* lesions and blood reactions in guinea pigs with the 5 c.c. of milk used for inoculation.

TABLE XII.—A COMPARISON OF THE ANTIBODY AND CELLULAR CONTENT OF THE FORE MILK AND STRIPPINGS OF REACTING MILK NOT CAPABLE OF CAUSING TYPICAL *BACT. ABORTUS* LESIONS IN GUINEA PIGS WITH THE 5 c.c. USED FOR INOCULATION.

(Agglutination reaction when various quantities of milk were added to test tubes containing bacterial suspension.)

	Right Rear Quarter.						Right Front Quarter.						Left Rear Quarter.						Left Front Quarter.					
	0.1 c. c.	0.05 c. c.	0.025 c. c.	0.01 c. c.	0.005 c. c.	Cells per c. c.	0.1 c. c.	0.05 c. c.	0.025 c. c.	0.01 c. c.	0.005 c. c.	Cells per c. c.	0.1 c. c.	0.05 c. c.	0.025 c. c.	0.01 c. c.	0.005 c. c.	Cells per c. c.	0.1 c. c.	0.05 c. c.	0.025 c. c.	0.01 c. c.	0.005 c. c.	Cells per c. c.
Cow No. 105:																								
Fore Milk.....	+	+	+	P	–	240,000	+	+	+	P	–	90,000	+	+	+	P	–	3,500,000	+	+	+	–	–	1,800,000
Strippings.....	P	P	–	–	–	60,000	P	P	–	–	–	30,000	P	P	P	–	–	2,500,000	P	P	–	–	–	1,200,000
						A.						A.						A.						A.
Cow No. 71:																								
Fore Milk.....	–	–	–	–	–	60,000	–	–	–	–	–	630,000	+	+	+	–	–	300,000	+	P	–	–	–	30,000
Strippings.....	–	–	–	–	–	90,000	–	–	–	–	–	600,000	+	+	P	–	–	210,000	–	–	–	–	–	90,000
						B.						B.						B.						B.
Cow No. 89:																								
Fore Milk.....	+	+	+	–	–	3,600,000	+	+	P	–	–	120,000	+	+	+	–	–	1,800,000	P	P	–	–	–	150,000
Strippings.....	+	P	P	–	–	120,000	P	P	–	–	–	180,000	+	+	+	P	–	300,000	P	P	–	–	–	330,000
						A.						A.						A.						A.

A. Guinea pigs inoculated with 5 c.c. of milk from each quarter did not develop *Bact. abortus* lesions and blood reaction.

B. Guinea pigs inoculated with 5 c.c. of milk from each quarter did not develop *Bact. abortus* lesions or blood reactions. Milk from L. R. quarter produced typical lesions in guinea pigs 2 years previously.

Here we see a tendency for the strippings to have a lower antibody and cellular content than the fore milk. It seems to the writer that this might be due to the fact that infection is slight and of such a superficial nature that any antibodies and cells resulting may easily be washed away with the early portion of the milking.

Part II.

A Study of the Effect of *Bacterium abortus* upon Man.

The investigations of Schroeder and Cotton, Fabyan, Moore, Zwick and Krage, Evans, Williams, Cooledge, and others prove that the organism *Bact. abortus* is often present in milk when drawn from apparently normal cows. It is further shown that this organism is sometimes present in great numbers, and that the infected milk may be pathogenic for guinea pigs when five cubic centimeters are inoculated intra-abdominally. That this bacterium is the causative organism of infectious abortion in cattle, and will produce serious lesions in guinea pigs, and affect other experimental animals, is generally admitted. These facts have led a number of investigators to fear that milk containing this organism might be pathogenic for human beings, especially for children whose principal food is often raw cows' milk.

In writing of this organism Melvin says in this connection: "This bacillus may prove to be another danger in the use of raw milk as food, and may furnish an additional reason for taking advantage of the safeguard afforded by pasteurization."

Note:—The author wishes to thank Mr. I. F. Huddleson for making many of the tests tabulated in Part II of this paper.

Mohler and Traum, in studying the pathogenicity of this organism to man, examined the sera from forty-two human beings by complement fixation and agglutination tests, using *Bact. abortus* as antigen. No positive results were obtained by these tests. The authors say: "Out of fifty-six tonsils and adenoids inoculated into guinea pigs, tonsil No. 3 produced nodular areas in the liver, but cultures from this organ remain sterile. Tonsils from case No 8, inoculated into two guinea pigs, showed in one of them after three months distinct lesions of infection in the liver, spleen, and testicles, and B. abortus was obtained from the lesions."

Larsen and Sedgwick have made an extended study of human infection by this organism. They state: "If the *B. abortus* is pathogenic for human beings, as it is for guinea pigs, and can be transmitted through the digestive tract, as is the case with cattle, we would expect infants and children to be the subjects most frequently infected. We have to date examined the blood of four hundred and twenty-five children by the complement fixation methods, and have found at least some support of the above expressed hypothesis. Of these four hundred and twenty-five cases we found seventy-three positive and three hundred and fifty-two negative reactions. In other words, the blood of seventeen per cent contained antibodies against *B. abortus*." The same authors in an attempt to answer the question: "Are these antibodies in the blood of children the result of an active or passive immunity?" examined a number of samples of milk from cows that had recently aborted, without being able to demonstrate the presence of *Bact. abortus* antibodies.

In their later investigations Sedgwick and Larsen found that newborn children who had not received cows' milk gave negative blood reactions in all of forty-two cases tested. One infant, taken from the breast on the seventh day after birth and fed on cows' milk, gave a positive reation on the twenty-first day. Positive reaction was obtained in two children with enlarged spleens; children with many common diseases of childhood, including rickets, gave negative reactions.

Nicholl and Pratt also obtained positive agglutination reactions with the blood sera of some children. In regard to their significance they say:

"The presence of serum reactions is suggestive, but they again are not conclusive, failing the isolation of the bacillus from the lesions. That the ingestion of bacilli in large doses may be followed by the presence of antibodies in the blood, has been demonstrated by several investigations. . . ."

Ramsey examined the blood of one hundred and sixteen children, of whom fifty-eight were boys and fifty-eight were girls. Of these, seven cases gave a positive complement fixation reaction—six boys and one girl.

That this reaction of the blood of children may indicate a passive immunity due to the ingestion of milk containing the antibodies is suggested by the work of Ehrlich and Wassermann, who found that young mice are capable of assimilating antitoxin through the intestinal canal and of storing it in the blood, thus acquiring a certain degree of passive immunity.

The author has shown in another part of this paper that *Bact. abortus* antibodies are often present in milk as it comes from the udder of an

apparently normal cow, that these antibodies are often due to a local *Bact. abortus* infection, that one or more quarters may show the antibodies while the others are negative, and that the reaction may spread from quarter to quarter, or may gradually die out.

TECHNIC EMPLOYED.

The technic employed for the complement fixation and agglutination tests was the same as described in Part I of this paper. That *Bact. abortus* antibodies are often present in milk in great concentration has been shown in the data tabulated in Part I of this paper.

The fact that antibodies are often present in milk leads us to suspect that the cases in which the appearance of antibodies in the blood of children have been looked upon as indicating infection, by *Bact. abortus*, are more probably due to an absorption of antibodies from the milk in the intestine and a consequent passive immunity.

An examination has been made of the sera of a number of persons drinking raw milk, pasteurized milk, and no milk, by the complement fixation and agglutination tests using *Bact. abortus* as antigen. The result of this work is shown in Table I.

TABLE I.—SHOWING THE PRESENCE OF ANTIBODIES FOR *BACT. ABORTUS* IN THE BLOOD OF ADULTS.

	Agglutination Test.					Complement Fixation Test.				Remarks.
	.1 c. c.	.05 c. c.	.025 c. c.	.01 c. c.	.005 c. c.	.1 c. c.	.04 c. c.	.02 c. c.	.005 c. c.	
Mr. A.....	+	P	–	–	–	+	P	–	–	Drinking raw cream.
Mr. B.....	–	–	–	–	–	–	–	–	–	Drinking raw milk.
Mr. C.....	P	–	–	–	–	P	–	–	–	Drinking raw milk.
Mrs. D....	+	+	–	–	–	+	P	–	–	Drinking raw milk.
Mr. E.....	–	–	–	–	–	–	–	–	–	Drinking raw milk.
Mr. F.....	–	–	–	–	–	–	–	–	–	Drinking raw milk.
Mr. G.....	–	–	–	–	–	–	–	–	–	Drinking Past. milk.
Mr. H.....	–	–	–	–	–	–	–	–	–	Drinking Past. milk.
Mr. I.....	–	–	–	–	–	–	–	–	–	Drinking Past. milk.
Mr. J.....	–	–	–	–	–	+	–	–	–	Drinking Past. milk.
Mr. K.....	–	–	–	–	–	–	–	–	–	Drinking no milk.
Mr. L.....	–	–	–	–	–	–	–	–	–	Drinking no milk.
Mr. M.....	–	–	–	–	–	–	–	–	–	Drinking no milk.
Miss N....	–	–	–	–	–	–	–	–	–	Drinking no milk.

In this table it is seen that of the six persons who had been drinking raw milk or cream, previous to the test, three (or 50 per cent) gave a reaction to the complement fixation and agglutination tests. Of the four persons drinking pasteurized milk, one gave a reaction to the complement fixation test only. All four who had been drinking no milk gave negative reactions.

Mrs. D., whose blood reacted to the test, had been drinking milk from Cow 71. Milk from one quarter of this cow's udder contained the *Bact. abortus* antibodies as shown in Table No. II, Part I.

Mr. A., of Table I, whose blood gave a strong reaction when this test was made, had been drinking about a pint of raw cream daily during the summer.

The findings of other investigators and the results shown in Table I

satisfy the writer that the presence of the antibodies in human sera are due to the ingestion of infected milk, and might indicate active infection or merely a passive immunity due to the absorption of antibodies from the milk.

To determine whether or not *Bact. abortus* antibodies could be made to appear in the sera of adults by ingestion of infected milk a feeding experiment was arranged. To obtain milk for this experiment cows were selected whose milk had a high *Bact. abortus* antibody content, and caused *Bact. abortus* lesions and blood reactions when five cubic centimeters were inoculated into the abdominal cavity of guinea pigs. During the twelve weeks of this experiment the milk was tested twice a month. The highest and lowest antibody content of the milk during this period is shown in Table II.

TABLE II.—SHOWING THE *BACT. ABORTUS* ANTIBODY CONTENT OF THE MILK FED IN WORK REPORTED IN TABLE III.

Cow.	Lowest antibody content.									Highest antibody content.								
	Agglutination test.					Complement fixation test.				Agglutination test.					Complement fixation test.			
	.1 cc.	.05 cc.	.025 cc.	.01 cc.	.005 cc.	.1 cc.	.4 cc.	.02 cc.	.005 cc.	.1 cc.	.05 cc.	.025 cc.	.01 cc.	.005 cc.	.1 cc.	.4 cc.	.02 cc.	.005 cc.
91.....	+	+	+	–	–	+	+	P	–	+	+	+	–	–	+	+	+	P
71.....	+	+	+	–	–	+	+	P	–	+	+	+	+	P	+	+	+	P
105....	+	+	+	–	–	–	–	–	–	+	+	+	–	–	+	+	+	–
107....	+	+	+	P	–	–	–	–	–	+	+	+	–	–	+	+	+	–
77.....	+	+	P	–	–	P	–	–	–	+	+	+	–	–	+	+	+	–
81.....	+	+	+	P	–	+	P	–	–	+	+	+	P	–	+	P	–	–

During the experiment shown in Table III each person was drinking daily for a period of eight weeks about a pint and a half of the milk shown in Table II. The antibody content of the human sera at the start, at the highest concentration during the test, and four weeks after the individuals had ceased to drink the milk, is shown.

TABLE III.—SHOWING THE ANTIBODY CONTENT OF HUMAN SERA, AT START, AT HIGHEST POINT, AND AT 4 WEEKS AFTER LAST DRINKING.

	Agglutination Test.					Complement Fixation Test.			
	.1 c. c.	.05 c. c.	.025 c. c.	.01 c. c.	.005 c. c.	.1 c. c.	.04 c. c.	.02 c. c.	.005 c. c.
Mrs. A. Start	+	P	−	−	−	+	P	−	−
Highest	+	+	+	−	−	+	+	−	−
After 4 weeks	+	+	+	−	−	P	−	−	−
Mr. B. Start	−	−	−	−	−	−	−	−	−
Highest	−	−	−	−	−	P	−	−	−
After 4 weeks	−	−	−	−	−	P	−	−	−
Mr. G. Start	−	−	−	−	−	−	−	−	−
Highest	+	−	−	−	−	P	−	−	−
After 4 weeks	−	−	−	−	−	−	−	−	−
Mr. C. Start	P	−	−	−	−	P	−	−	−
Highest	+	+	−	−	−	P	−	−	−
After 4 weeks	−	−	−	−	−	−	−	−	−
Mr. L. Start	−	−	−	−	−	−	−	−	−
Highest	+	−	−	−	−	P	−	−	−
After 4 weeks	−	−	−	−	−	−	−	−	−
Miss N. Start	−	−	−	−	−	−	−	−	−
Highest	−	−	−	−	−	−	−	−	−
Mr. K. Start	−	−	−	−	−	−	−	−	−
Highest	−	−	−	−	−	−	−	−	−
After 4 weeks	−	−	−	−	−	−	−	−	−

That *Bact. abortus* antibodies may appear in human sera, while an individual is drinking a *Bact. abortus* infected milk which is rich in antibodies, is shown in the above table. Of the seven persons drinking this milk there was an increased antibody content in the sera of five (or over seventy per cent).

If the *Bact. abortus* antibodies present in the blood were due to an infection of the individual by organisms being present in the milk, it seems that we could expect a fairly high and lasting antibody content. On the other hand, if the antibodies present are due to a passive immunity, we could expect but a weak reaction, which would persist for but a short time after one had ceased drinking the milk. It seems to the writer that the data given in the table suggest that the antibodies present are due to a passive immunity. We have the individuals drinking an enormous amount of antibodies daily and in over seventy per cent of the cases an increase in the antibody content of the blood during the eight weeks. In every instance the reaction is weak and shows a tendency to die out when the infected milk is no longer being fed. The fact that individuals were apparently in perfect health at all times during this experiment is a further indication that there was no active infection.

That the *Bact. abortus* antibodies sometimes found present in human blood are due to a passive immunity and are not due to an active infection is further indicated by an experiment shown in Table IV.

TABLE IV.—SHOWING THE *BACT. ABORTUS* ANTIBODY CONTENT OF HUMAN BLOOD SERUM WHILE INDIVIDUALS ARE DRINKING A MILK WHICH DOES NOT CONTAIN *BACT. ABORTUS* ANTIBODIES BUT TO WHICH A PURE CULTURE OF THIS ORGANISM WAS ADDED.

	Agglutination Test.					Complement Fixation Test.			
	.1 c. c.	.05 c. c.	.025 c. c.	.01 c. c.	.005 c. c.	.1 c. c.	.04 c. c.	.02 c. c.	.005 c. c.
Mr. C.									
Start	+	P	–	–	–	P	–	–	–
2 weeks	+	P	–	–	–	P	–	–	–
4 weeks	+	P	–	–	–	+	–	–	–
6 weeks	–	–	–	–	–	+	P	–	–
8 weeks	–	–	–	–	–	+	–	–	–
Mr. G.									
Start	–	–	–	–	–	–	–	–	–
2 weeks	P	–	–	–	–	P	–	–	–
4 weeks	P	–	–	–	–	P	–	–	–
6 weeks	P	–	–	–	–	P	–	–	–

In Table III it is shown that in a high percentage of the cases there was a noticable increase in the *Bact. abortus* antibody content of the blood, when individuals were drinking a naturally infected milk which was rich in antibodies. In the experiment, the results of which are shown in Table IV, milk was selected that had a negative *Bact. abortus* antibody content. A pint of this milk, to which 10 c.c. of a 48-hour broth culture of *Bact. abortus* was added, was drunk daily by each person in the test. In the table it will be noticed that there is no appreciable increase in the *Bact. abortus* antibody content when the individuals are drinking the milk and culture. While this test couldn't be carried out in as extensive a manner as desirable the results suggest that in Table IV the reaction is due to a passive immunity previously acquired and not to an active infection caused by the presence of *Bact. abortus.*

TABLE V.—FURTHER TESTS SHOWING THE PRESENCE OF ANTIBODIES FOR *BACT. ABORTUS* IN THE BLOOD OF ADULTS.

		Agglutination Test.					C. Fixation Test.				Remarks.
		.1 c.c.	.05 c.c.	.025 c.c.	.01 c.c.	.005 c.c.	.1 c.c.	.04 c.c.	.02 c.c.	.005 c.c.	
Mr. A.	2–21–17.........	+	+	–	–	–	–	–	–	–	Drinking past. milk.
	3– 1–17.........	–	–	–	–	–	....	....	....	....	
	3–10–17.........	–	–	–	–	–	–	–	–	–	
	3–15–17.........	–	–	–	–	–	–	–	–	–	
Mr. B.	2–21–17.........	+	+	+	–	–	–	–	–	–	Drinking raw milk.
	3– 1–17.........	....	....	....	....	....	....	....	....	....	
	3–10–17.........	+	+	–	–	–	–	–	–	–	
	3–15–17.........	+	+	–	–	–	–	–	–	–	
Mr. C.	2–21–17.........	+	+	–	–	–	–	–	–	–	Drinking raw milk.
	3– 1–17.........	+	–	–	–	–	+	–	–	–	
	3–10–17.........	+	P	–	–	–	–	–	–	–	
	3–15–17.........	–	–	–	–	–	–	–	–	–	
Mr. D.	2–21–17.........	–	–	–	–	–	+	–	–	–	Drinking little raw milk.
	3– 1–17.........	–	–	–	–	–	....	....	....	....	
	3–10–17.........	+	–	–	–	–	+	–	–	–	
	3–15–17.........	–	–	–	–	–	P	–	–	–	
Miss E.	2–21–17.........	+	+	+	–	–	–	–	–	–	Drinking raw milk.
	3– 1–17.........	+	+	–	–	–	–	–	–	–	
	3–10–17.........	+	+	P	–	–	–	–	–	–	
	3–15–17.........	+	P	–	–	–	–	–	–	–	
Miss F.	2–21–17.........	–	–	–	–	–	–	–	–	–	Drinking past. milk.
Mr. G.	2–21–17.........	+	–	–	–	–	+	+	P	–	Drinking raw milk.
	3– 1–17.........	+	+	+	–	–	–	–	–	–	
	3–10–17.........	+	+	+	–	–	+	–	–	–	
	3–15–17.........	+	+	–	–	–	+	+	–	–	
Mr. H.	2–21–17.........	–	–	–	–	–	–	–	–	–	Drinking past. milk.
	3– 1–17.........	+	–	–	–	–	+	+	–	–	
	3–10–17.........	+	+	–	–	–	–	–	–	–	
	3–15–17.........	–	–	–	–	–	–	–	–	–	
Miss I.	2–21–17.........	P	P	–	–	–	P	–	–	–	Drinking raw milk.
	3– 1–17.........	....	....	....	....	....	....	....	....	....	
	3–10–17.........	P	P	–	–	–	–	–	–	–	
	3–15–17.........	P	P	–	–	–	–	–	–	–	
Mr. J.	2–21–17.........	–	–	–	–	–	+	–	–	–	Drinking past. milk.
	3– 1–17.........	+	+	–	–	–	–	–	–	–	
	3–10–17.........	+	+	+	–	–	–	–	–	–	
	3–15–17.........	+	+	–	–	–	–	–	–	–	
Mr. K.	2–21–17.........	+	+	–	–	–	–	–	–	–	Drinking raw milk.
	3– 1–17.........	+	P	–	–	–	–	–	–	–	
	3–10–17.........	+	+	+	–	–	–	–	–	–	
Mr. L.	2–21–17.........	–	–	–	–	–	–	–	–	–	Drinking past. milk.
	3– 1–17.........	–	–	–	–	–	–	–	–	–	
	3–10–17.........	–	–	–	–	–	–	–	–	–	
	3–15–17.........	P	–	–	–	–	–	–	–	–	
Mr. M.	2–21–17.........	+	–	–	–	–	–	–	–	–	Drinking past. milk.
	3– 1–17.........	–	–	–	–	–	–	–	–	–	
	3–10–17.........	+	–	–	–	–	–	–	–	–	
	3–15–17.........	+	–	–	–	–	–	–	–	–	
Mr. N.	2–21–17.........	+	+	–	–	–	+	–	–	–	Drinking raw milk.
	3– 1–17.........	+	+	+	–	–	+	P	–	–	
	3–10–17.........	+	+	+	–	–	–	–	–	–	
	3–15–17.........	+	+	–	–	–	–	–	–	–	
Mr. O.	2–21–17.........	+	–	–	–	–	+	–	–	–	Drinking a little raw milk.
	3– 1–17.........	+	–	–	–	–	+	–	–	–	
	3–10–17.........	+	–	–	–	–	+	–	–	–	
	3–15–17.........	+	–	–	–	–	P	–	–	–	
Miss P.	3– 1–17.........	–	–	–	–	–	P	–	–	–	Drinking past. milk.
	3–10–17.........	–	–	–	–	–	–	–	–	–	
Mr. Q.	3– 1–17.........	–	–	–	–	–	–	–	–	–	Drinking raw milk.
	3–10–17.........	P	P	–	–	–	–	–	–	–	
	3–15–17.........	+	–	–	–	–	–	–	–	–	
Mr. R.	3–10–17.........	P	–	–	–	–	+	–	–	–	Drinking raw milk.

TABLE VI.—SHOWING THAT LOW PASTEURIZATION TEMPERATURES WILL NOT DESTROY *BACT. ABORTUS* AGGLUTININS IN MILK AND CREAM.

	Agglutination Test.				
	.1 c. c.	.05 c. c.	.025 c. c.	.01 c. c.	.005 c. c.
Whole raw milk	+	+	+	–	–
Held 60°C., 20 min	+	+	+	–	–
" 30 min	+	+	+	–	–
" 40 min	+	+	+	–	–
Held 63°C., 20 min	+	P	–	–	–
" 30 min	+	P	–	–	–
" 40 min	+	P	–	–	–
Held 65°C., 20 min	+	+	–	–	–
" 30 min	P	P	–	–	–
" 40 min	P	P	–	–	–
Whole raw cream	+	+	+	P	–
Held 60°C., 20 min	+	+	+	–	–
" 30 min	+	+	+	–	–
" 40 min	+	+	P	–	–
Held 63°C., 20 min	P	P	–	–	–
" 30 min	P	P	–	–	–
" 40 min	–	–	–	–	–
Held 65 C., 20 min	–	–	–	–	–
" 30 min	–	–	–	–	–
" 40 min	–	–	–	–	–

In Table V will be found further tests showing the presence of antibodies in the blood of adults drinking milk. Here again we see a tendency for the antibodies to appear more regularly in the blood of those drinking raw milk. In instances in which the antibodies appear in the blood of those drinking pasteurized milk there is the possibility of their being derived from the ingestion of other dairy products which are not pasteurized or are pasteurized at a temperature not sufficient to destroy the antibodies present. The individuals tested in Table V eat more or less ice cream which is made from cream pasteurized at a temperature of 60° C. for 30 minutes. That this temperature is not sufficient to destroy the antibodies may be seen in Table VI. Experiments have shown that a momentary temperature between 70° C. and 75° C. is necessary to destroy the agglutinins.

Part III.

Facts Disclosed in a Study of the Presence of *Bact. abortus* in Milk by Means of the Agglutination Test.

INTRODUCTION.

Through the studies of other investigators and the results shown in another part of this paper we know that *Bact. abortus* is often present in the milk of apparently normal cows. It is also shown that the organism present in the cow's udder is in a virulent form capable of causing very pronounced lesions when five cubic centimeters of the milk are injected intra-abdominally into a guinea pig.

In an early part of this paper it is shown that this infection of the udder may be detected by means of the so-called serum tests when blood serum is replaced by milk as the substance to be tested. In this

part of the paper we take advantage of this fact in making a study of the prevalence of *Bact. abortus* infected udders, the methods by which the udders become infected, the permanence of the infection in the udder, and other questions of a practical nature.

It is possible that this test may be of help in detecting infected milk in order that it may be eliminated as possibly one of the important factors in the spread of the disease.

Very little work has been done upon the possibility of this infection being transmitted to the young through the milk. Huddleson says in this regard: "That *Bact. abortus* antibodies develop in calves as a result of ingesting naturally infected milk seems to us to be a demonstrated fact, but the cause and significance of the appearance of the antibodies cannot be explained until further development of the studies on the calves. The antibodies may be due to an active infection, they may be due to an active immunity or they may be due to a passive transmission of the antibodies present in the milk."

Schroeder states that Cotton and he have succeeded in causing the abortion disease in guinea-pigs by feeding them seemingly normal milk from apparently healthy cows that had become chronic carriers of the abortion bacillus.

McFadyean and Stockman consider the digestive tract one of the means by which the abortion organism gains entrance to the bodies of cows.

In the studies tabulated in this part of the paper the agglutination test is largely depended upon as it has been shown that the agglutination and complement fixation tests correspond so closely that the two tests are not required when milk is used as a test substance.

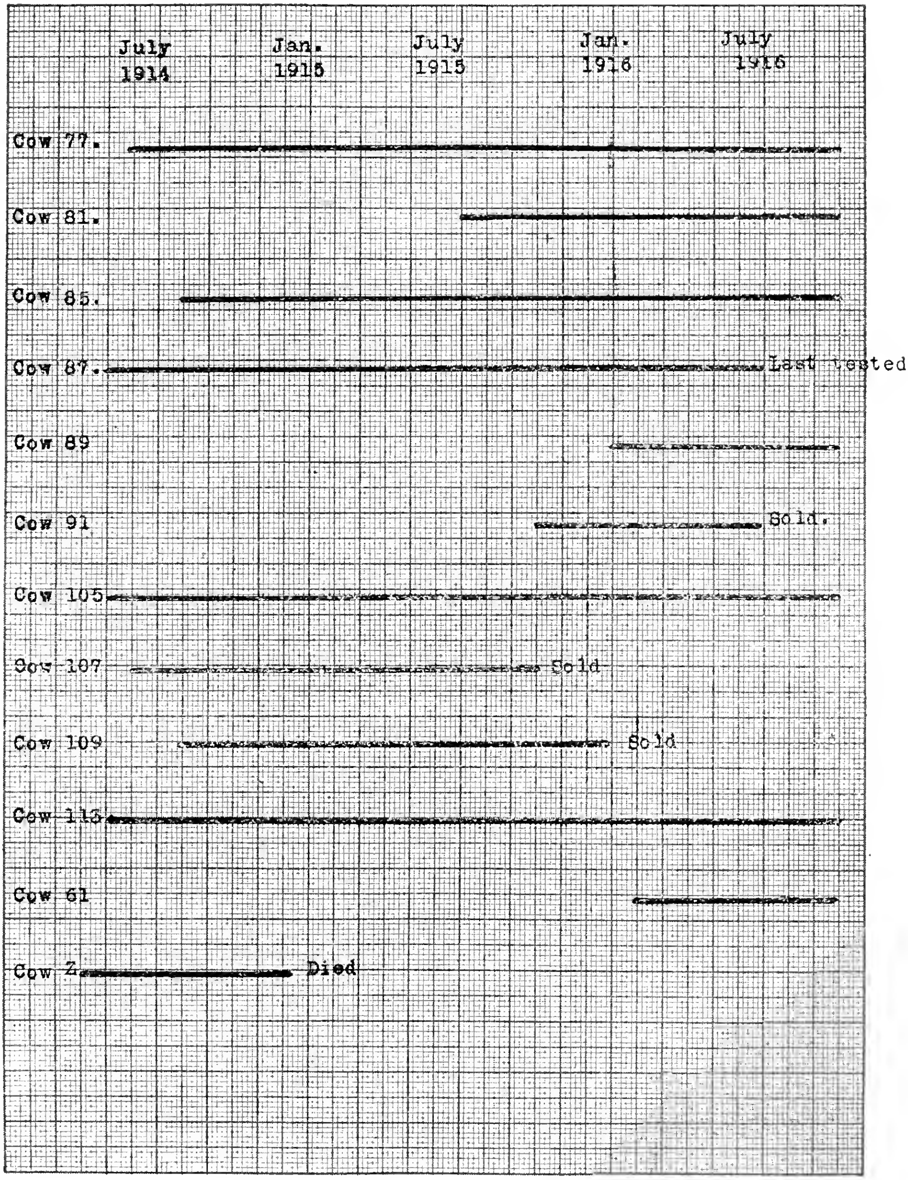
To get an idea of the prevalence of this form of *Bact. abortus* infected udders a number of farms was visited and samples of fore milk taken from each quarter of each cow. These were brought to the laboratory at once and agglutination tests made. In some instances the samples stood over night in the ice box. Experiments have shown that such delay does not influence the results. The results of this study are given in Table I.

TABLE I.—SHOWING THE PREVALENCE OF *BACT. ABORTUS* INFECTED UDDERS IN HERDS STUDIED.

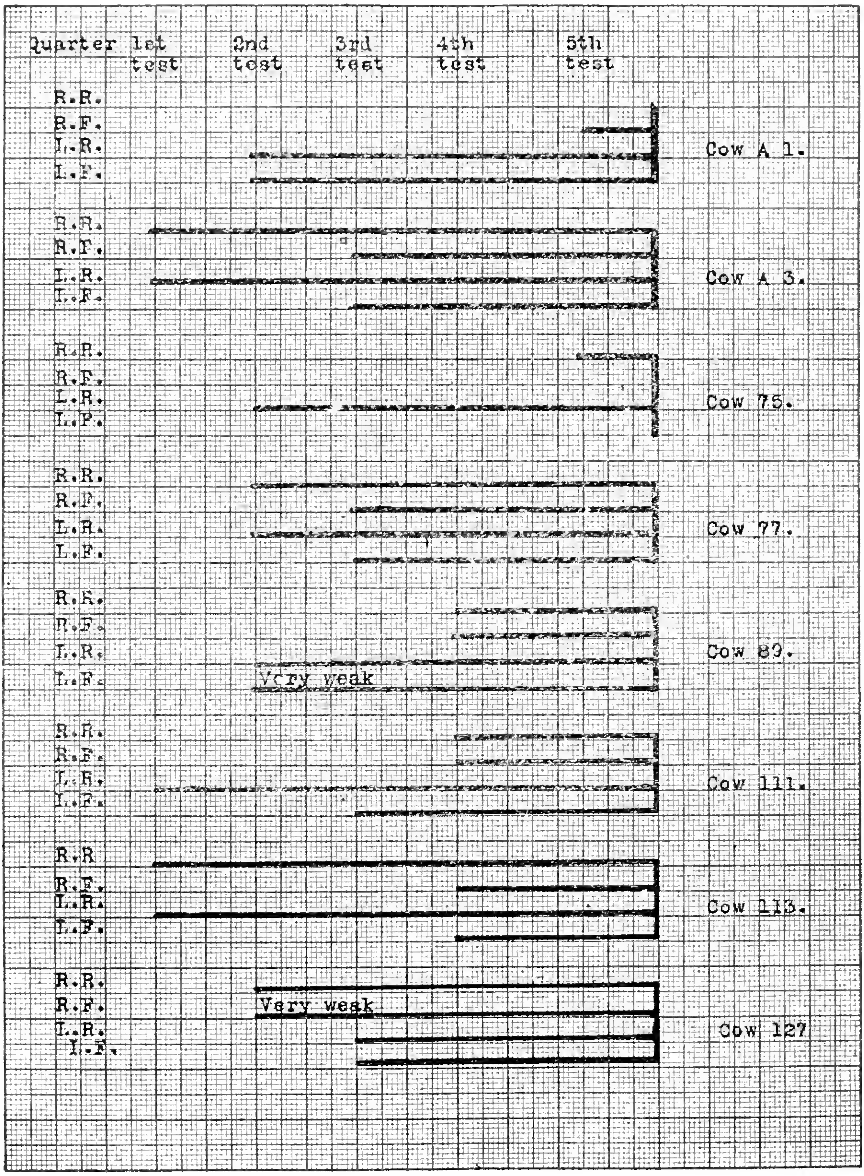
Farm.	Cows tested.	Number of infected udders.	Per cent infected udders.	Remarks.
A	26	0	0	Certified dairy.
B	40	9	22	
C	9	0	0	
D	15	5	33	
E	13	2	15	Beef cattle.
F	7	6	86	
G	2	2	100	
H	6	4	67	

The data tabulated in Table I show that this infection of the udder is very common in this part of the state at least. The first five farms in the table were selected at random for study and probably give a better idea of existing conditions than the whole table. The farms F and G

Graph. I. Showing the duration of *Bact. abortus* infection in Cow's udders.



Graph. II. Showing the first appearance of *Bact. abortus* infection in cow's udder.



were selected for study because they were known to be badly infected. Another thing worthy of notice in this table is that the infection is either present in a high percentage of the animals of a herd or is not present at all, which condition may be due to the very infectious nature of this disease of cattle.

To show the duration of *Bact. abortus* infection when once established in the cow's udder tests have been made at intervals of six weeks covering a period of three years. These are tabulated in Graph I.

It will be noticed that once the infection becomes established the milk remains a possible source of infection for years. In no cow under observation has the infection died out after becoming firmly established.

In hopes of throwing some light upon the manner in which the udder becomes infected with *Bact. abortus* the results shown in Graph II were tabulated to show the first appearance of the antibodies in the milk of the various quarters. In some instances it will be noticed that the reaction is first shown to appear in two quarters at the same time. This is probably due to the fact that as the milk was tested only at intervals of six weeks there was time for the reaction to appear and spread from quarter to quarter before it was again tested. In several instances which are not shown in this Graph the reaction had spread to all four quarters when tested after a regular negative test six weeks previously. In these instances we have no way of telling which quarter was the first to show the reaction.

In Graph II it will be noticed that one or the other, or both of the rear quarters were the first to show the reaction in five of the eight cases. In the three other instances, one of the rear quarters and one of the front quarters show the reaction at the same test. As the front quarters of two of these cows gave a very weak reaction while the rear quarters were very strong it seems safe to conclude that in these two instances the rear quarters were first to show the infection also. In the other instances it is impossible to say definitely whether the left rear or left front quarter was the first to show the reaction.

The fact that the rear quarters are the first to show this infection points to the genital discharges as the probable source of the infection. In infection of the genital tract the discharges are often found to contain *Bact. abortus* in a virulent form. Through switching the tail which often becomes coated with this infectious material, or because of the discharges running down the back of the udder the rear quarters would naturally be the first to become infected. The infection could then be spread to the other quarters upon the hands, during the milking process. These facts seem to point to the genital discharges as the original source of the infected udder.

To prevent this infection from spreading to the udder and thus making the milk unsafe by becoming a possible disseminator of the infection, steps should be taken to prevent the discharges from coming in contact with the teats.

The age of a number of the cows that developed *Bact. abortus* infected udders while under observation is tabulated in Table II.

TABLE II.—SHOWING THE AGE AT WHICH INFECTION FIRST APPEARED IN THE UDDERS OF COWS UNDER OBSERVATION.

Cow Number.	First appearance of infection.	Age of cow at first appearance of infection
75	12–10–15	2 yr. 10 mo.
77	6–16–15	2 yr. 3 mo.
89	7–12–16	10 yr. 5 mo.
91	10–10–15	3 yr. 11 mo.
95	1–22–16	7 yr.
97	2– 2–16	11 yr. 2 mo.
115	3–29–16	9 yr. 3 mo.
119	3–30–16	5 yr. 4 mo.
121	3–30–16	6 yr. 4 mo.
133	8–31–16	3 yr. 2 mo.
137	10–26–16	3 yr.

The animals in this table are in a herd which has been under observation the past three years during which time an average of about 20 per cent of the udders have been infected. The percentage of cows present with infected udders would have greatly increasd but for the fact that a number of the animals have been sold while others have died during this period. It will be noticed that the age of the animals apparently has no connection with the first appearance of the infection.

SUMMARY AND CONCLUSIONS.

Part I.

There is apparently no connection between the *Bact. abortus* antibody content of the blood and that of the milk.

The *Bact. abortus* antibody content of milk may vary from quarter to quarter indicating that the antibodies present are due to local infection and do not come from the blood stream.

The agglutination test as compared with the complement fixation test for *Bact. abortus* infection when using milk instead of the blood serum gives the higher percentage of positive reactions, and is apparently more reliable.

A pure culture of *Bact. abortus* introduced into the milk cistern of a cow's udder caused the appearance of agglutinins in the milk.

In every case in which *Bact. abortus* was found present in the milk by animal inoculation the agglutinins for this organism were also found, but this bacterium was not found in every case in which agglutinins were demonstrated.

The agglutinins may be present in the milk of cows that have aborted and in the milk of cows that have never aborted.

The antibodies may be present in one or more quarters, may spread from quarter to quarter, and may gradually die out.

As high or a higher antibody and cellular content in the strippings than in the fore milk seems to indicate active infection and the presence of *Bact. abortus* in the milk in sufficient numbers to produce the typical

lesions and blood reactions when five cubic centimeters are inoculated into the abdominal cavity of guinea-pigs.

A lower antibody and cellular content in the strippings than in the fore milk seems to indicate that infection is slight and that *Bact. abortus* is not present in sufficient numbers to cause infection with the five cubic centimeters used for inoculation.

The agglutination test is of value in studying the presence of *Bact. abortus* in milk when it is desired to study a large number of samples.

If *Bact. abortus* is found to be pathogenic for humans, this test may be of value in safeguarding certified and all unpasteurized milk.

If this disease is found to be spread to calves through ingestion of infected milk this test may prove a means by which such milk could be eliminated for this purpose.

SUMMARY AND CONCLUSIONS.

Part II.

We have no proof that *Bact. abortus* is pathogenic for human beings.

It is possible to cause antibodies for *Bact. abortus* to appear in the blood serum of adults by feeding a milk which is naturally infected with *Bact. abortus* and which contains the *Bact. abortus* antibodies.

Antibodies appearing as above apparently indicate a passive immunity due to the absorption in the intestine of the antibodies present in an infected milk.

SUMMARY AND CONCLUSIONS.

Part III.

Twenty-seven per cent of the cattle studied upon seven farms had *Bact. abortus* infected udders.

The infection was either present in a high percentage of the animals of the herd or was entirely absent indicating the very infectious nature of the disease.

Once the infection is established in the udder the milk becomes a carrier of *Bact. abortus* and a possible source of the infection for years. In no instance has the udder infection died out after being firmly established during the three years that observations have been made.

The rear quarters are usually the first to show the *Bact. abortus* infection indicating that the genital discharges and switching of the tail are its source. The infection may then be carried to the front quarters upon the hands.

The age of the cow apparently has no connection with the first appearance of the infection.

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RED ROCK WHEAT.[1]

Circular No. 31.

By F. A. Spragg and A. J. Clark.[2]

SUMMARY.

Red Rock is a new variety of wheat that has just recently been introduced among farmers. It is by far the best wheat that has yet been produced for Lower Michigan by the Experiment Station. Sixty bushels were sent to as many farmers in the fall of 1914.[3] It was possible for each farmer who received a bushel to raise all the seed he wished to plant in 1915 and have some for sale. This statement is borne out by the fact that thirty-three sales of farm-grown Red Rock were made through Professor Shoesmith in the summer of 1915. These sales averaged nearly eleven bushels (10.85 bu.). This means that after the growers had sown all they wished and furnished seed to neighbors as far as desired, 358 bushels were sold to farmers of other parts of the state. Besides this, 69 bushels were sent out from the College to nearly as many farmers in 1915. It is likely that a thousand bushels of Red Rock were used as seed in the fall of 1915, insuring a reasonable yield for the benefit of farmers who wish to get the best available wheat for 1916 planting. Such people may buy the seeds through the Secretary of the Michigan Experiment Association, East Lansing, Michigan.

SOURCE.

The Red Rock wheat comes from an individual kernel picked out of a white wheat (Plymouth Rock) and planted in the fall of 1908. It was given the number 97003 and is listed in Table I of Bulletin 268 as Bearded Rock. Since that time Red Rock has been considered as describing the variety better, though it is a bearded red wheat. It also has a red chaff (contrary to the table above mentioned).

QUALITIES.

The principal characteristics of Red Rock are: exceptional winter hardiness, high yield, extra stiff straw, and those characteristics that yield a bread far above that usually produced from Michigan grown wheats. The fact that it is a red wheat of unusually high quality, and that

1. This is an extension of Bulletin 268. That bulletin reported data up to July, 1912, and this continues from that date.
2. The baking tests were made under the direction of Prof. A. J. Clark and reported herewith together with yield and milling tests.
3. Prof. V. M. Shoesmith distributed this wheat as Secretary of the Michigan Experiment Association.

it is a pure wheat, is saying a great deal, when we consider the vast amount of white and mixed wheat that Michigan is growing. Red Rock is out-yielding the best of the white as well as all types of wheat so far tested at the College. It is no longer profitable to grow the softer types as the price on white and mixed wheat is being cut $50 to $120 per car below the market for No. 2 Red wheat. Fig. 1 shows a loaf of bread from Red Rock flour at the left and a loaf from a representative white wheat flour at the right. These loaves were made at the same time and under the same conditions.

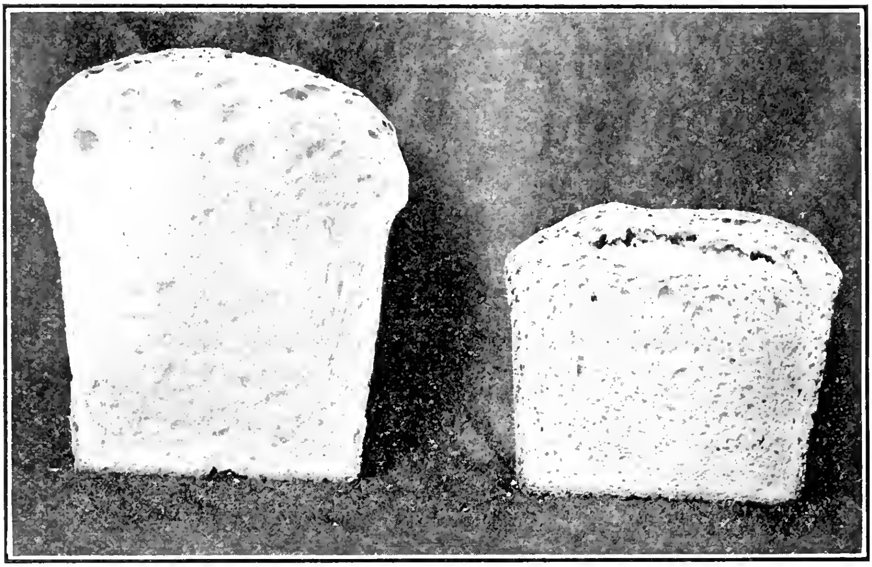

FIG. 1.

The unusual hardiness of Red Rock appeared in the spring of 1912 from its endurance of the ice sheets of the previous winter and the production of about four times as much grain as the check of that year (viz. Shepherd's Perfection). Red Rock is shown in the left of Fig. 2, where it shows a good stand between two wheats that were badly winter killed. Since that time, the Red Rock has been used as a check (or standard) in the wheat variety series.

The extreme stiffness of its straw was previously observed but it was especially tested in 1914. The wheat variety series had been planted on a clover sod that year and as a result the straw grew exceptionally tall. The heads of the wheat could in many places touch the rim of one's hat. A series of rainy spells came just before harvest. The wheat lodged badly and several of the varieties went flat, yet the Red Rock always found its way up until it stood erect at harvest time. During the rainy harvest of 1915 a strip of Red Rock on the College farm was not cut until two weeks after being fully ripe, and during these two weeks the piece received a series of rains, yet it was still standing when cut and had not lost its grain.

The yield of Red Rock has been from a third to a fifth better (on the average) than any other wheat tested with it during the years 1912 to 1915. This fact is brought out forcibly in Table I entitled "Some Wheat Comparisons on a Percentage Basis."

FIG. 2.

TABLE 1.—SOME WHEAT COMPARISONS—ON PRECENTAGE BASIS. MICHIGAN EXPERIMENT STATION, 1912-1915.

Variety	Yield	Milling Test	Baking Test % Michigan Standard Flour		
	% Red Rock	% Flour	Protein	Wt. Loaf	Vol. Loaf
American Banner	74.3	60.0	107.1	100.5	96.6
Buda Pesth	68.3	64.8	110.3	99.4	97.1
Shepherd's Perfection	58.8	63.7	107.9	101.2	96.4
Plymouth Rock	73.4	65.7	101.2	100.7	87.2
Early Windsor	76.9	61.5	103.5	101.2	94.1
Red Rock	100.0	62.6	123.0	100.0	112.0
Mealy	57.8	61.2	114.4	101.3	97.5
European Century	87.1	63.5	112.5	98.7	106.7
Craig's Favorite	86.9	67.3	121.7	102.0	108.4
Stoner "Miracle"	73.4	68.9	117.3	100.0	93.1
Berkley	79.1	65.8	124.3	102.4	100.4
Rock	67.3	61.7	122.5	102.7	106.1
Babcock	84.7	65.1	125.6	102.3	102.4
Early Ripe	72.7	58.3	110.4	99.5	109.8
Michigan Standard Flour	....	....	100.0	100.0	100.0

In the first column, Red Rock is considered 100%. This is the average for the years mentioned above. During the same years Red Rock has averaged about forty bushels per acre. It will be noticed that several of the varieties yielded less than 75% of Red Rock, that is, less than thirty bushels per acre when compared on the same basis. These, too, include such high quality Michigan wheats as American Banner, Shepherd's Perfection, Plymouth Rock, and Early Windsor, these being the best wheats that the College had to offer before Red Rock came on the scene.

The three columns to the right give the results of analysis for protein content and of the baking tests. The flour used as the standard in these tests was produced by blending equal amounts of Michigan wheat flours obtained from sixteen representative mills. This composite flour was

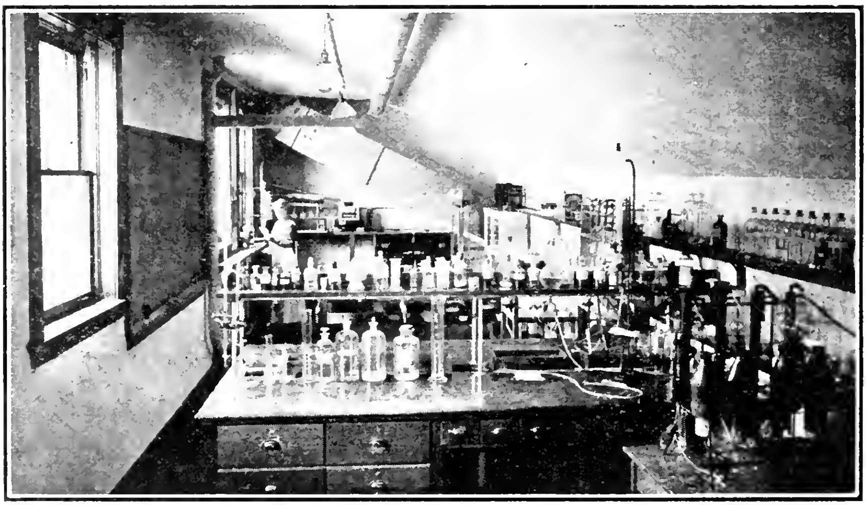

Fig. 3.

termed the "Michigan Standard," representing 100%. It will be noted that on this basis Red Rock flour contains 123% as much protein as the Michigan Standard and that the volume of the loaf is 112% of that of the standard, showing the flour from this wheat to be of a much higher grade than the average Michigan wheat flour.

WHAT FARMERS THINK OF RED ROCK WHEAT.

"I think the Red Rock is the coming wheat as soon as the farmers find out the difference between it and other varieties."—L. H. Remus, Adrian.

"Red Rock is the best wheat that I have ever raised, yielding 42 bushels per acre and weighing 61 pounds per bushel."—Horace Bliss, Chesaning.

"Very much pleased with Red Rock wheat. It yielded 12 bushels more per acre than my old variety and ripened a little earlier."—B. W. Cade, Haslett.

"Red Rock wheat looks very good to me, being a much hardier wheat than our Red Wave."—W. G. Boyd & Sons, Waldron.

"After two years experience with growing Red Rock wheat, I would say that it is extremely hardy and will out-yield our local varieties by at least 10 bushels per acre."—Fred F. Cornair, Chesaning.

"The Red Rock wheat which I secured from you produced a yield of 44½ bushels per acre, while my old variety yielded 32 bushels per acre."—Ferdinand Sperling, Saginaw.

Mr. Kurt Sell of Walled Lake and Eugene Strang of Ypsilanti report 64 pounds per bushel from Red Rock wheat, and perhaps a dozen other farmers reported weights above sixty pounds per bushel.

May 14, 1916.—"Have a fine stand of Red Rock now."—J. C. Otto, Middleville.

"The wheat (Red Rock) and rye (Rosen) that we got look fine, the best I ever had."—George B. Pardee, Galien.

The last two are especially interesting as much winter killing occurred last winter.

BARLEY IMPROVEMENT.

Circular No. 32.

By F. A. Spragg.

SUMMARY.

The search for better barleys has been in progress at the Michigan Experiment Station for at least ten years, and so far as can be seen at present, the success of this investigation lies in the production of two winter barleys that are hardy enough to stand Michigan winters when they are planted about September 1st or before, but are uncertain when planted after the 15th of September. All the tests that have so far been made in the Upper Peninsula have been planted late and like most of such plantings in the Lower Peninsula have been failures. Up to the present time, winter barley has not been a commercial success north of the Ohio river. Experience shows that the winter barley must cover the ground with a vigorous growth by the time that winter sets in if it is to winter well. The tops freeze down completely, usually below the winter lodging-place of the Hessian fly, thus killing the fly and these frozen tops protect the crowns of the plants.

The outline map, Figure 1, exhibits the location of tests of winter barley. Small dots represent those that were planted in 1914 but from which no reports have been received. A circle around the dot marks a report. The figures give yields when known. Four of these are 60 bushels and above, while a half dozen others exceed 50 bushels per acre. The 1915 yield from Michigan Winter barley at the College was 59.3 bushels per acre, notwithstanding the fact that these plants were loaded with Hessian fly the fall before. This was a seven-acre piece planted September 4, 1914. A plain circle indicates a 1915 planting, the condition of which is unknown (spring 1916). When the circle has been filled to make a large dot the reported stand is good to excellent. A line cutting the circle signifies winter killing. A partially filled circle marks a report between these two extremes. Almost all of these tests were planted late, falls 1914-1915.

The prominent fact in nearly all of these reports is that the farmer is convinced that late planting (i. e., after September 15th) is uncertain and usually means failure. On this point, Mr. George C. Wheaton of Marshall reports: "A twenty-acre field was planted to barley about September 28th (1915). Two-thirds of the plants did not survive the winter. They were small last fall and had no tops to protect the roots. Another field was planted on August 30th and is a very nice A No. 1 stand."

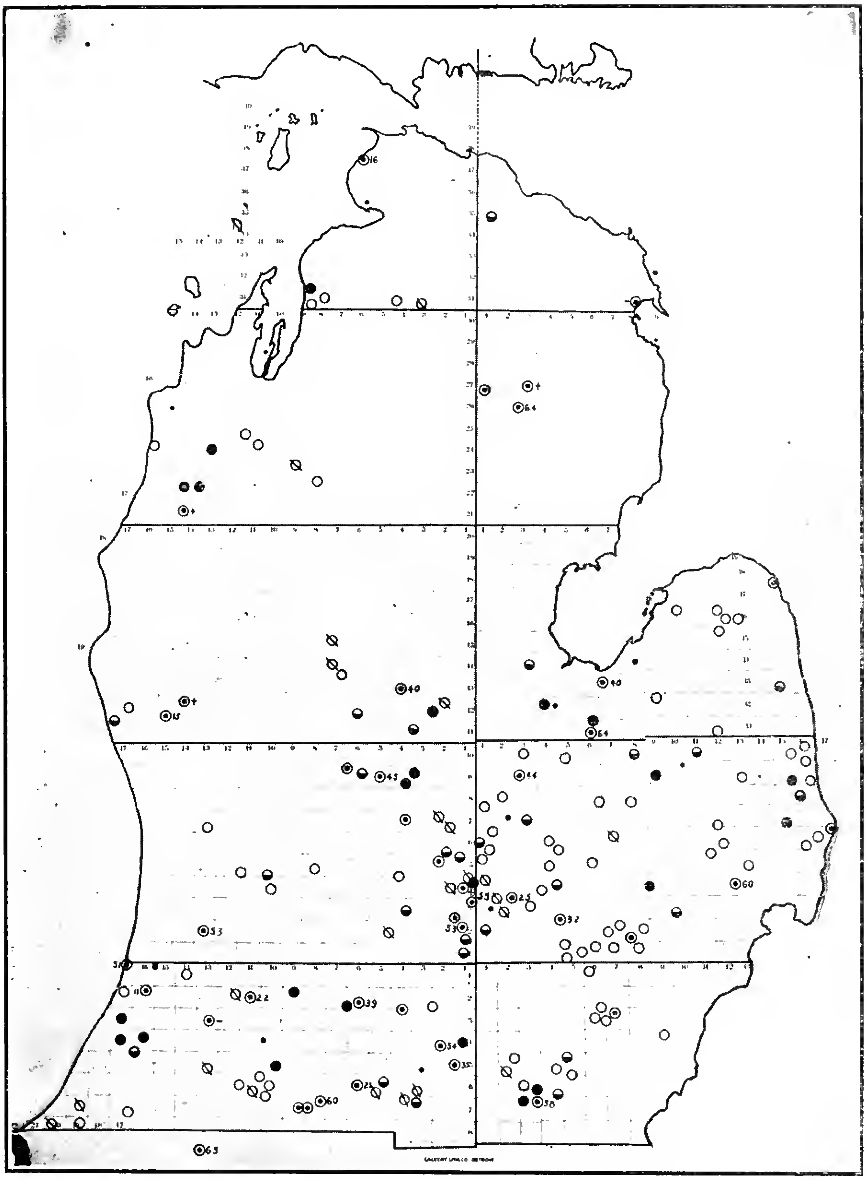

Fig. 1.

During the seasons of 1913-1915, the yield of the Michigan Winter barley (at the College) has averaged 58.9 bushels per acre. During the same seasons the Derr Winter has averaged seven bushels less, or 51.7 bushels per acre. The average production of barley in Michigan is set at 25 bushels per acre by the U. S. Department of Agriculture. If planted early and generally grown, these winter barleys may double the average yield of barley in the state. A yield of 59 bushels of barley equals 88½ bushels of oats when compared on the basis of pounds of grain per acre.

HISTORY.

The early work in this investigation was testing the existing varieties on point of yield. As the common commercial variety is a mixture, it was determined in 1907 to begin the work of purifying these strains. Since that time, pedigreed pure lines, the progeny of single mother plants, have been tested in variety series. Only a few highly recommended

FIG. 2.

varieties were at first tested. Finally in 1910 the station got a large number of barleys from different parts of the world. Most of these came through the U. S. Department of Agriculture. Some had been bred by the Department and other experiment stations. The barleys received for 1910 were planted a single seed in a place, five inches apart in the row, and five inches between the rows. Thus several thousand plants grew from single seeds that year and the best ones were selected to become mothers of plant rows in 1911. A variety series of the best of the spring strains were run during 1912, 1913 and 1914.

Figure 2 shows the 1913 series of spring barleys, and Table I records the three-year results with the winter barleys compared with the best spring varieties found by this investigation. As Michigan barleys, which are of good color and plumpness, are most valuable for feed purposes, the prime aim is to produce high-yielding varieties. The principal grain competitor is oats, but since a bushel of oats is only two-thirds as many pounds as a bushel of barley, we cannot compare these crops on the basis of bushels per acre. Valued on the basis of pounds of grain per acre, 40 bushels (1920 pounds) of barley equal 60 bushels of oats.

The old standard oats (Alexander) has averaged 64.7 bushels for the past six years and the new standard oats (Success) has produced 75.5 bushels per acre for the past four years. No spring barley has yielded as much as 40 bushels per acre, on a three-year average. Thus it can be clearly seen that not only the large number of poor yielding varieties of barley that Michigan is growing, but the best spring barley that this investigation has been able to find, is producing less feed per acre than the high grade varieties of oats.

TABLE I.—YIELD TEST 1912-1915.

Strain No.	Acc. No.	Variety	Yield in percent of Oderbrucker					Bus. per A.	Yield above Oderbrucker Bu. per acre
			1912	1913	1914	1915	Av. %		
00703	13	Michigan Winter...	155.45	173.15	196.67	170.09	173.84	58.9	25.0
00803	14	Derr Winter.......	135.29	144.14	185.76	145.13	152.58	51.7	17.8
01404	4	Oderbrucker.......	100.00	100.00	100.00	.	100.00	33.9	0.0
02304	20	Heil's Hanna No. 4.	79.33	117.94	108.49	.	101.92	34.6	.7
02502	22	Franconian........	95.66	114.97	132.57	.	114.40	38.8	4.9
02708	24	Heil's Hanna No. 1.	91.92	123.58	123.80	.	113.10	38.3	4.4
03202	29	Manshury.........	103.24	115.43	126.45	.	115.02	39.0	5.1

From the above table all strains or varieties of barley that yielded less than Oderbrucker have been omitted. The highest yielding Oderbrucker is taken as 100% in the table, and the other varieties compared with it from year to year. The general average shows that Michigan Winter is about one and three-fourths times as productive as Oderbrucker, while the Derr Winter yields a half more. In the last column may be seen the number of bushels per acre in excess of the yield of the Oderbrucker.

WINTER BARLEYS.

The work with winter barleys began with Mr. H. B. Derr's selections for testing in this section. They were planted in the fall of 1909 in beds, i. e., a single seed in a place five inches apart from its neighbor. Two of the eight lots winter-killed as a whole the first season. A third lot was injured enough to be proven distinctly inferior, and was discarded as a whole.

Eight selected plants were saved out of the remaining five sources to become mothers of plant-rows planted in the fall of 1910. In 1911, two of these strains (all that remained from another of the sources) were discarded, as they had been injured by the winter. This left six strains, from four of the original sources, to be tested by the winter of 1911-1912. The fall rains soaked the ground before freezing and the temperature reached 30° below. This was a testing time that the weather man tells us has not been repeated since 1884. A very large portion of the wheats in Southern Michigan were killed or badly injured that winter, and most of the wheats in the Michigan Station's variety series were badly injured. The six strains of winter barley were tested that winter along with the wheats, and as a result all of the strains of another source (the Wisconsin Winter barley) had disappeared. This left a strain of barley

from each of three different sources to be tested further in 1913, and the best two to be increased in 1914.

Figure 3 shows the two barleys that were increased at East Lansing in 1914. The view was taken in the spring of 1912 and shows the injury done to wheats on either side. The barley to the left is No. 00703 (Michigan Winter) and the one at the right is No. 00803 (Derr Winter). As compared with wheats these two barleys appeared to be superior in vigor and yielding power, if not also in winter hardiness. They certainly stood an extreme test, under which many wheats were killed in the winter of 1911-1912.

FIG. 3.

Figure 4 shows the three winter barleys (five plats) in the wheat variety series, spring 1913. The plat to the left of the man is our standard wheat, Red Rock. The plat where he stands is the only representative of the barley, No. 00203. The two plats to the right of the man (his left) are duplicates of those to the left of the standard wheat. The stand of barley in these plats was much better than the stand of the wheat in the plats on either side. The yield of grain that year was 59.7 bushels per acre for the Michigan Winter and 49.7 bushels for the Derr Winter.

Figure 5 shows these two strains being increased at East Lansing. They were ripe June 24, 1914, and ready to thresh on July 3. The area of each piece was .5683 of an acre. The yield of grain that year was 57.7 bushels per acre for the Michigan Winter and 54.5 bushels for the Derr Winter.

Twenty pounds of each of these barleys were sent to each of the places represented by small dots in Figure 1, fall of 1914, including three tests in the Upper Peninsula. Between six and seven acres of each of these barleys were also planted at the College. The yield was 59.3 bushels per acre from the Michigan Winter and 50.3 bushels from Derr Winter in 1915. The three-year average has already been given (Table 1). The results are best seen in Figure 1.

FIG. 4.

WEATHER CONDITIONS.

The season of 1915 was abnormal in being cold and rainy during July, August and September. It was so wet in some sections that farmers had a hard time to gather their crops at all, especially the small grains. The harvest of winter barley escaped this wet weather, as it was ripe and could easily be housed before the rain set in.

After harvest the ground almost everywhere was so wet that it could not be plowed in season. This fact together with the fact that corn and beans could not be harvested until about October 1st put off the preparation of land for winter crops until late September or early October. Much of the land that had been intended for fall crops was not planted, and what was planted was either poorly prepared, planted entirely too late, or both.

The winter of 1915-1916 was unusually hard on fall crops partly (and in many cases mainly) because of the short growth and poor root develop-

ment, partly because of lack of sufficient snow for protection from changes in temperature; warm weather in winter would at times start growth which was later frozen. Ice and water smothered the crops in many cases. These facts largely account for the failures reported by farmers in the spring of 1916.

FIG. 5.

WHAT FARMERS THINK OF WINTER BARLEY.

REPORTS OF 1915.

"Threshed 59 bushels from one and one-half acres. (40 pounds of seed.) I have planted 33 acres of the same. If the fly and hard winters do not kill the plants I think it will be the corn crop on my farm."—George C. Wheaton, Marshall.

"I think the new winter barley a good farm crop."—George E. Linn, Williamston.

"Well pleased with crop."—C. S. Foster, East Lansing.

"The crop did well. It surely has a place on the Michigan farm. It is easy to grow and comes early."—C. B. Cook, Allegan.

"Seed you sent me last fall got lost. Did not get it until September 27, but I sowed it then. I saved all that lived through and sowed it the 11th of September. I think it will be a splendid crop for this (Oscoda) county."—Will K. Hunt, Red Oak.

"I am very much in favor of winter barley as a crop. It furnishes early feed just when this sort of feed is needed most. It is a success in Elkhart County, Indiana,—yielded 60 bushels per acre."—C. L. Coffeen, (Goshen, Indiana,) County Agent, now located at Adrian, Michigan.

"I am pleased to say that we have found winter barley a very satisfactory crop during the past season. Mr. Veitengruber reported a yield of 64 bushels to the acre."—Earl P. Robinson, County Agent, Saginaw, W. S.

"Yielded 57 bushels, machine measure."—E. G. Knight, Hanover.

"My crop did not have a fair start in 1914. Many plants did not get root growth to stand the winter. Yielded 44.3 bushels per acre."—Fred F. Cornair, Chesaning.

"The winter barleys, Michigan and Derr, bid fair to find a permanent place in our agriculture."—Gifford Patch, Moscow.

"Came through the winter 100% alive; yielded at rate of 60 bushels per acre."—D. E. Williams, Bronson.

"I think winter barley is the coming crop for the farmers of Michigan."—Walter Potts, Mason.

"I threshed a yield of 58 bushels per acre. I believe it is a great crop on light soils."—L. H. Remus, Adrian.

"I consider winter barley a very good crop. I have sown seven acres this fall."—W. B. Clark, Howell.

"The Michigan Winter stood the weather better than the Derr Winter."—J. Robert Duncan, Vicksburg.

REPORTS OF STAND, MAY, 1916.

Requests were sent out to about a hundred farmers who got winter barley to plant in the fall of 1915. Some of these reported that on account of the wet weather they were unable to get it in at all. Of those that planted the barley a very few planted it before the 25th of September while most of the plantings were in October. A few that got their pieces in early report good stands. One of these men, as already reported above, has an excellent stand from a piece planted August 30 and a failure from a piece planted late in September. The outline map, Figure 1, shows the amount of successes among these reports. The growers in general are usually convinced that winter barley must be planted early to insure success. The average stand of all the reports is 46%. It is interesting that at least one good stand came from east of Traverse Bay, and one medium stand from Cheboygan County.

WHAT FARMERS SAY.

"I sowed the bushel of winter barley the fore part of September, and it went into the winter in good shape. It is 90% of a perfect stand."—Amos Hanlon, Middleville.

"It is lacking about one-fifth of a good stand. Am satisfied that it was sown a little too late."—Frank Gilbert, Brethren.

"The winter barley looks real nice now. The outlook is prosperous."—Ben Nelson, Brethren.

"Winter barley is 80% of a crop. We think favorably of crop. Was sown on September 24, due to rain."—C. W. Simpson, Mendon.

"The volunteer barley, where I harvested last year's crop, has come on fine. Some of it is a foot high with no signs of injury."—Gifford Patch, Moscow.

"Would consider the prospects about 90%."—R. E. Morrow, Central Lake.

"L. J. Wilson's barley shows up fairly well. I think it shows rather remarkable hardiness considering the lateness of the seeding (October). Winter barley still looks good to me."—C. L. Coffeen, County Agent, Adrian.

"Mr. John Veitengruber, Frankenmuth, has a splendid field of four or five acres of winter barley. I think it is too thick, if anything."—Earl P. Robinson, County Agent, Saginaw, W. S.

"Those that sowed their barley early have a good stand. The barley is a delight if given a chance. I will seed 15 acres this fall."—W. S. Potts, Mason.

LITERATURE

WINTER BARLEY, by H. B. Derr, U. S. Department of Agriculture, Farmers' Bulletin 518, p. 18, Fig. 4.

REPORT OF THE SOUTH HAVEN EXPERIMENT STATION.

Professor H. J. Eustace, Horticulturist:

I submit this report of the South Haven Sub-station for the year ending June 30, 1917.

During the past season, this Station has been mainly concerned with plant breeding and experimental spraying.

SPRAYING.

Scale Spraying.

Materials Used.	Quantity Used.
Scalecide	1 gallon to 15 gallons water.
Concentrated Lime-sulphur	1 gallon to 8 gallons water.
Soluble sulphur	1 pound to 4 gallons water.
Sherwin-Williams Dry Lime-sulphur	1 pound to 4 gallons of water.
Sherwin-Williams Dry Lime-sulphur	1 pound to 3½ gallons of water.

Applications were made on April 26, 27 and 28, on trees which the past season had shown some indications of scale. All of the trees that were sprayed, however, were only slightly affected with scale.

There was much variation in the results due to a lack of uniform conditions under which the applications were made. It was, therefore, impossible to arrive at any definite conclusions as to the effectiveness of the various mixtures.

Control of Plant Lice on Apples.

Applications were made on young trees of Wagner, Wealthy and Oldenburg, which seemed to be infested with plant lice to about the same degree. They were quite numerous at the time of the first spraying but at the time of the second application, not enough could be found to make a count and were not present in large enough quantities after this to make it an object to do further work.

Materials Used.

Nicotine sulphate, 40%, one ounce to eight and a quarter gallons, combined with lime-sulphur, and scalecide, one gallon to thirty gallons.

Dates of Applications.

First application on April 24th. Fruit buds were swelling and leaf buds just showing green. The plant lice collected mostly on the swelling buds and in moderate quantities.

Second application on May 20th. Fruit buds were showing pink and the lice were not so prevalent and more scattering, occurring mostly around the flower buds.

Tabulation of Results.

NICOTINE

Limb	First count	Second count					
	Total insects	Total insects	Number dead	Number alive	Number missing	Total dead missing	Per cent dead and missing
1	42	16	14	2	26	40	....
2	23	23	20	3	0	20	....
3	24	15	15	0	9	24	....
4	23	8	0	8	15	15	....
5	9	2	2	0	7	9	....
6	56	38	11	27	18	29	....
7	11	11	11	0	0	11	....
Total	188	113	73	40	75	148	80.3
Scalecide							
1	54	33	23	10	21	44	....
2	27	19	5	14	8	13	....
3	58	51	26	25	7	33	....
4	2	2	0	2	0	0	....
5	14	11	3	8	3	6	....
Total	157	116	57	59	39	96	61.1
Check							
1	75	66	0	68	7	7	....
2	25	25	0	25	0	0	....
3	45	43	0	43	2	2	....
Total	145	136	0	136	9	9	6.5

Nicotine gave the best control and no injury was noted either from it or the Scalecide from the first application but at the time of the second spraying, considerable injury was done to the tender leaves on trees sprayed with Scalecide, enough to warrant not using it for this purpose when the fruit buds are showing color. However, it is possible that Scalecide can be used effectively by making a late application for scale and aiming to control the first appearing plant lice at this time.

DRY ARSENATE OF LEAD AND ARSENITE OF CALCIUM AS A POISONED SPRAY FOR APPLES.

The object of this work was to obtain data on the comparative value of the two poisons as used upon apples for the control of the larvae of the codling moth.

Applications were made upon a collection of varieties and data taken upon its effectiveness against the codling moth. Notice was also taken of the point of entrance of the larvae as to whether it entered through the calyx or the side of the fruit.

These poisons were combined with the summer strength of lime-sulphur and three different applications were made.

Results were as follows:

Spray	Total fruits	Number sound	Percent sound	Larvae entering the side	Percent entering the side	Larvae entering the end	Percent entering the end
Lead arsenate....	3,889	2,891	74.3	562	14.4	176	4.5
Calcium arsenate.	10,669	5,331	49.9	1,784	16.7	1,929	18.0
Check...........	4,427	1,764	39.8	1,143	25.8	845	19.0

No injury could be determined from either of the poisons used and there was little difference in the handling, mixing and weathering qualities of the two poisons.

PEACH SPRAYING.

Spraying was done in a block of mixed varieties. Two applications were made for fungous troubles. Results were computed from forty-three varieties.

Mixtures used were Atomic sulphur, 5 pounds to 50 gallons, self-boiled lime-sulphur, 8-8-50, and hydrated lime and sulphur 8-8-50. The Atomic sulphur was added to a small amount of water, thoroughly mixed with it and then poured in the spray tank which contained the required amount of water. Self-boiled lime-sulphur was prepared in the usual manner. Hydrated lime and sulphur was made as follows: Eight pounds each of hydrated lime and sulphur were sieved and thoroughly mixed dry, then made into a paste by adding two gallons of boiling water. Six more gallons of boiling water were added and the whole mixture was stirred for five minutes and then cooled by adding 8 gallons of cold water. Dry arsenate of lead was added to all mixtures at the rate of 1¼ pounds to 50 gallons for the first application only.

All trees were given an application of strong lime-sulphur for leaf curl and again on June 16th, all trees were sprayed with an application of arsenate of lead and lime for curculio. On July 7th, the first spraying of the three mixtures was made and the second and last application was made on August 15, omitting the earlier varieties. Weather conditions after this being very dry, further spraying was not considered necessary.

Brown Rot was the only fungous trouble which made its appearance to any extent and tabulated data on this is as follows:

Spray	Total fruits	Sound fruits	Brown rot	Percent rot
Atomic sulphur..................................	3,125	2,941	84	2.7
Self boiled lime-sulphur.........................	3,690	3,560	130	3.4
Hydrated lime-sulphur..........................	2,411	2,262	149	6.1
Check..	2,108	1,986	122	5.7

The variability of the results was in all probability caused by making the application upon so many varieties, as these varieties showed varying susceptibility to fungous troubles and some of the check trees produced as sound fruit as some which were sprayed.

Spray injury to fruit, if occurring, was not noted. Peach Scab and Bacteriosis occurred on the leaves to some extent on all of the plots. The greatest amount was on the check trees, the Atomic sulphur trees being next in the amount of diseased leaves while the self-boiled lime-sulphur and hydrated lime-sulphur sprayed trees had only a small amount of infection. Peach Scab was also quite prevalent, as well as Brown Rot, on the check trees.

Hydrated lime and sulphur apparently weathers as well as the self-boiled lime-sulphur but it seems to be a coarser mixture which does not spread quite as readily as the self-boiled. However, for one trial, hydrated lime and sulphur gave good satisfaction and is worthy of further trial.

PLUM SPRAYING.

The mixtures used were concentrated lime-sulphur, 1 gallon to 40; Atomic sulphur, 5 pounds to 50 gallons; self-boiled lime-sulphur, 8-8-50 and Bordeaux mixture 4-4-50. To each of the above mixtures was added dry arsenate of lead, 1¼ pounds to 50 gallons of mixture for all applications.

These mixtures were applied on May 9th, 11th, 12th, 23d, June 12th and 13th. This work was done upon mixed varieties and included only one and sometimes two trees of a variety. Because of this fact, varying susceptibility to disease was encountered according to the variety and this factor has produced a considerable variation in the results.

The foliage of the trees sprayed with self-boiled lime-sulphur had the best appearance. In only one case was there any noticeable attack of Shot Hole fungus and this was a spring infection on one Stark Gage tree which did not develop to any extent. Atomic sulphur and commercial lime-sulphur gave about the same degree of control, there being only scattering leaves affected with the fungus. Two trees sprayed with the Bordeaux mixture suffered nearly complete defoliation from the disease and the fungus appeared to some extent upon most of the trees sprayed with this mixture.

Russeting of the fruit was quite general on the Gage trees but as this also occurred on check trees, it was not possible to attribute it to spray injury. Check trees seemed to develop leaf spot in accordance with their susceptibility. The Japanese varieties had considerable injury from this cause while some of the European varieties had only scattering leaves affected.

Results showed quite a lack of uniformity. With one exception, all of the trees sprayed with the Atomic sulphur failed to set a crop of fruit and this tree did not have enough to furnish any results. Likewise with the check trees only one produced any fruit and this one was fairly free from insects and diseases and did not prove a very reliable check.

GRAPE SPRAYING.

This work was done upon a plot of grapes containing about 30 varieties. Whenever possible, it was attempted to have some vines of each variety sprayed with each mixture as well as to leave checks.

Mixtures used were as follows:

Bordeaux, 2-2-50
Bordeaux, 3-3-50
Bordeaux, 4-4-50
Pyrox, 10 pounds to 50 gallons
Adheso, 7 pounds to 50 gallons

Dry arsenate of lead was added to the Bordeaux mixture at the rate of 1¼ pounds to 50 gallons for all applications.

Three applications were made of all the mixtures, on June 5th and 6th, 22d and 23d and again on July 18th.

The only troubles developing on the vines were Black Rot, Grape Berry Moth and Mildew and these occurred only in moderate amounts. Some foliage injury occurred on the Bordeaux sprayed vines though it is possible that some was caused by the extreme heat and drought of July and August. Examination of the vines showed that the degree of injury occurred relative to the mixture applied in the order as follows: Bordeaux 4-4-50, Bordeaux 3-3-50, Bordeaux 2-2-50;; Adheso and Pyrox. No spray injury on the fruit was noted.

During the past season pear psylla was very troublesome in this region, many growers not being aware of the presence of this insect and did not spray at the proper time. By mid-summer many orchards were badly infested. Cooperating with County Agent T. A. Farrand, an at-attempt was made to find a material to control the insect that could be safely used in the summer. Three mixtures were used: kerosene emulsion, 40%; Nicotine 1-800 and soap, and a mixture suggested by the N. Y. Experiment Station at Geneva, consisting of 40 pounds stone lime, 1 pint of nicotine and 1 gallon of lime-sulphur to 100 gallons. These mixtures were applied August 2d and 3d upon trees quite badly infested. A high pressure was maintained and two men with rods sprayed opposite sides of limbs at the same time. There was very little difference in the effectiveness of the three mixtures and control was far from complete, it being practically impossible to hit the majority of the insects. Later examinations seemed to show that the heavy wash containing the lime acted as a deterrent as fewer insects were found upon these trees than upon the other sprayed trees or the checks. No bad effect was noted upon either foliage or fruit of trees sprayed with the heavy mixture and by picking time no appreciable deposit remained upon the fruit.

This mixture may have some value as a summer spray but control should be by the late fall or early spring applications as in summer they are too active and protected too much by the foliage.

Plant breeding activities have been confined to tree fruits and grapes as before outlined.

A considerable number of varieties have been planted this year for use in breeding work. There are 76 varieties of tree fruits and grapes, 43 of brambles and 15 of foreign temperate zone fruits.

Considerable injury to peach fruit buds occurred on February 12, 1917, the minimum temperature at the Station on that date being 16 degrees below zero. Examination of 68 varieties showed the following to be the hardiest in bud and these in the order named: Longhurst, Horton's River, Wark, Engles, Billmeyer and Banner. Examination at blooming time verified these results. Some damage was done to the Japanese varieties of plums, Burbank showing the most injury. Other varieties suffered little if any injury.

Respectfully submitted,

I. R. NOTEWARE,

Superintendent.

South Haven, June 30, 1917.

THE CLIMATE

OF

MICHIGAN AND ITS RELATION TO AGRICULTURE

THESIS FOR DEGREE OF M. S.

DEWEY ALSDORF SEELEY.

1917

OUTLINE

THE CLIMATE OF MICHIGAN AND ITS RELATION TO AGRICULTURE.

DEWEY A. SEELEY.

INTRODUCTION.

The whole realm of human activities and pursuits is affected by weather conditions, but none more vitally than agriculture. The average of the weather conditions makes up climate, and an accurate description of the climate of any section can be used as a guide in determining the suitability of that section for particular crops, provided soil conditions are right for those crops.

It is the purpose of this paper to describe the climate of the state of Michigan and state its suitability to various crops. It will be necessary to enquire into the factors that determine climate, at the outset, in order to understand the peculiarities that will be noted in the climatic conditions in different sections of this state.

PART I.

FACTORS CONTROLLING CLIMATE.

Latitude, altitude, environmental conditions, and the location of a place relative to the path of storms, each has a decided influence on climate. Without going into detail with regard to each of these it will be sufficient to notice that the distance north or south of the equator, other things being equal, determines the temperature of a locality because the sun's rays strike the earth at a greater and greater angle with increasing latitude. In round numbers the average annual temperature decreases about one degree with each 100 miles north or south of the equator.

Altitude, or height above sea level, has an effect on temperature analogous to that of latitude. On the average the temperature decreases about one degree Fahrenheit with each rise of 300 feet in height. As a result the summits of high mountains are continually snow-capped throughout the year, even in the tropics. On the other hand slight elevations of ground which provide good air drainage are not subject to the extremes of low temperature or killing frosts to the extent that low, undrained areas are, because the cold air, being heavier than warmer air, drains off from the hill-sides into the swales. Low ground is sometimes colder by eight or ten degrees than higher ground near by.

Elevated sections usually receive more rainfall than lower areas, especially on the slope from which the prevailing winds blow, because the

currents of air which are forced to rise up the slope, expand and cool as they rise, thereby producing greater condensation and precipitation. It will be noted later that the effect of elevation on rainfall is noticeable even in Michigan where the differences in height above sea level are comparatively slight.

The third factor in the control of climate, that of environmental conditions, is one which is particularly important in Michigan. The effect of the Great Lakes is marked, especially along Lakes Michigan and Superior, causing wide departures in temperature and other climatic conditions, between those sections and other regions of the same latitude and altitude. Large bodies of water heat much more slowly in summer and cool correspondingly slower in winter, than adjoining land areas, so that the Great Lakes are cool in summer and warm in winter, compared with the temperature of interior land areas. This is due to the fact that from five to seven times the amount of heat necessary to raise the temperature of a given weight of soil one degree is required to warm the same weight of water an equal amount. The fact that considerable heat from the sun's rays is used up in evaporating some of the surface water also retards rapid heating. Water is usually in motion and any heating at the surface is transferred to other regions, whereas in the case of the soil this mixing does not take place and the surface becomes superheated, and this is another reason why the soil is warmer than water areas in summer. Furthermore insolation is transmitted and conducted through water much more readily than through soil, which is an additional cause of super-heating of the surface of latter compared to the former. As a result of these various factors actual tests of temperature of the water in the Great Lakes in mid-summer show readings as much as 30° F. to 40° F. lower than soil temperatures taken near the surface of the ground in the interior of the state at the same time. The prevailing westerly winds blowing across these wide expanses of comparatively cool water in summer are greatly reduced in temperature and reach the Michigan shore as cool, refreshing breezes.

The great volume of heat that is stored up in the lakes during the summer is held well into the winter season. In fact only in the very coldest winters does the water freeze solidly across, and then only for short periods. Therefore the extremely cold northwest winds which usher in typical cold waves in winter, are decidedly tempered in crossing the comparatively warm water and strike the eastern and southern coasts much moderated in temperature.

The fourth factor influencing climate is the location of the region relative to the normal storm path. Storms are areas of low atmospheric pressure which travel across the continents and oceans in a general west to east direction, sometimes retaining their identity clear around the world. On account of the fact that the winds blow spirally inward toward the center of these great low pressure areas, as they progress eastward, they are called "Cyclones." They are great atmospheric whirls, usually covering several states in extent, and travel easterly from 200 to 2,000 miles per day. The paths or routes that these disturbances travel are quite well defined. The majority of them move somewhat southeastward over the western half of the country, changing their course to northeastward when they reach a point a few hundred miles this side of the Rocky Mountains. The further south a storm

goes the more pronounced is the turn to the northward in the middle-western states. As a result the majority of storms pass the region of the Great Lakes and drift eastward out the St. Lawrence valley. These storm areas bring with them the typical change to warmer and unsettled weather, with rain or snow, according to the season.

Following these disturbances areas of high pressure or anti-cyclones usually arrive, bringing with them just the opposite sort of weather. Most of these formations first appear on the weather map in the far Northwest whence they move southeastward, many of them toward the Great Lakes. As the air flows out away from these areas, as cold, icy blasts in winter, the wind is northwest in advance of one of these anti-cyclones, sometimes reaching the required severity to be termed a "Cold wave." Now Michigan is in the direct path of the majority of both the cyclones and anti-cyclones, and the weather therefore swings back and forth from one type to the other in irregular intervals of three to five days. Rainfall is more or less evenly distributed throughout the year and monotonous periods of extreme conditions of any kind are infrequent and shore in duration. On the other hand regions remote from these storm paths are not so evenly watered and do not experience the fluctuating conditions of this section.

PART II.

THE CLIMATE OF MICHIGAN.

Having outlined the factors which control climate in general the peculiarities of the climate of Michigan will be more easily accounted for. The various elements which make up climate, i. e., temperature, precipitation, cloudiness, wind and humidity, will be taken up separately as they are found in this state and described in order.

Michigan lies almost entirely between 42° and 47° N. latitude, and is therefore about the same distance north of the equator as France, Switzerland, northern Italy, Austria and the Balkan States. Its climate is somewhat colder than the first three countries named but about the same in temperature as Austria and the northern portion of the Balkans. The ocean currents tend to cause milder weather in the three former. The average annual temperature ranges from about 39° F. in the coldest portions of the upper peninsula to 49° F. in the southern tier of counties. Chart II shows the isothermal lines for the year, and they indicate clearly the decrease in temperature with increase in latitude. The effect of altitude can be noticed by studying the elevations shown in Chart I in connection with the annual temperatures. The following will serve to illustrate this effect:

TABLE I.—EFFECT OF ELEVATION ON TEMPERATURE.

Station	Elevation, feet.	Mean annual temperature, degrees F.
Humboldt, Marquette County	1,536	36.9
Newberry, Luce County	773	39.3
Difference	763	2.4
Ann Arbor, Washtenaw County	930	47.1
Eloise, Wayne County	640	48.1
Difference	290	1.0
Hillsdale, Hillsdale County	1,150	47.1
Adrian, Lenawee Co	770	48.5
Difference	380	1.4

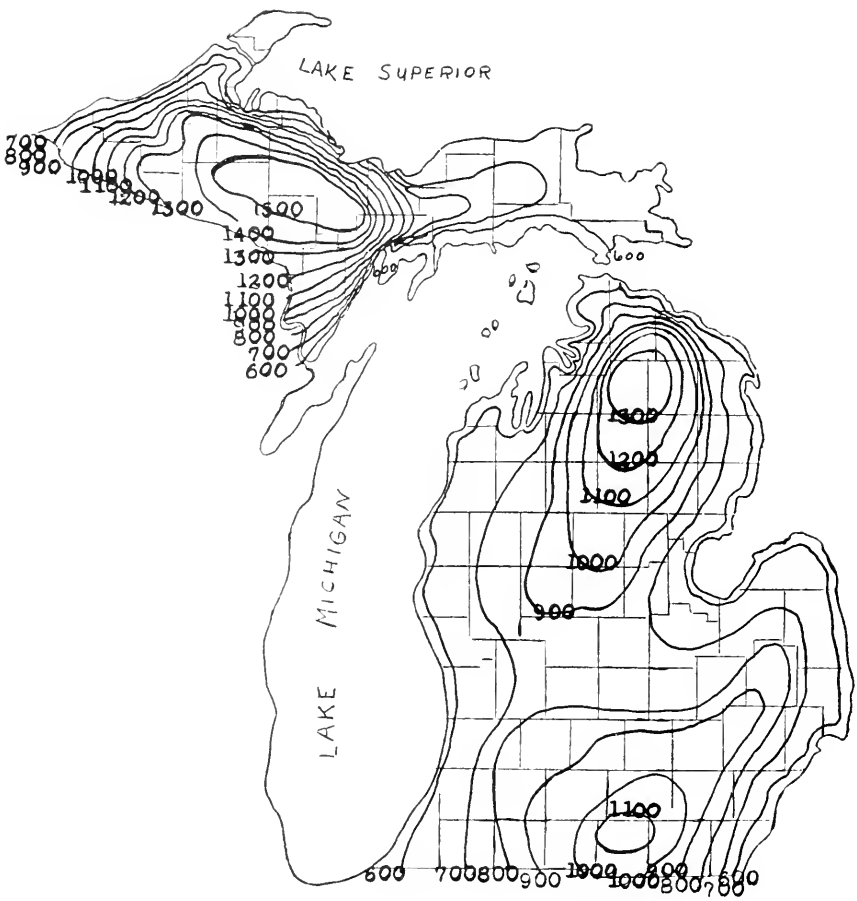

CHART I. Elevation of Michigan
in feet above sea level.

Each pair of stations was selected to show the true effect of elevation alone, other influences such as latitude, distance from lake, etc., being about the same for both stations in each pair.

The effect of the lakes on the mean annual temperature is evident, yet not as prounounced as it is in the case of either summer or winter temperatures. Chart II shows that the temperature is lower in the interior of the state than it is along the lake shores, but this is probably due more to the influence of elevation than lake effect. The cooling effect of the lakes in summer nearly balances the warming influence in winter, leaving the results for the year about the same as in the interior, at the same altitude.

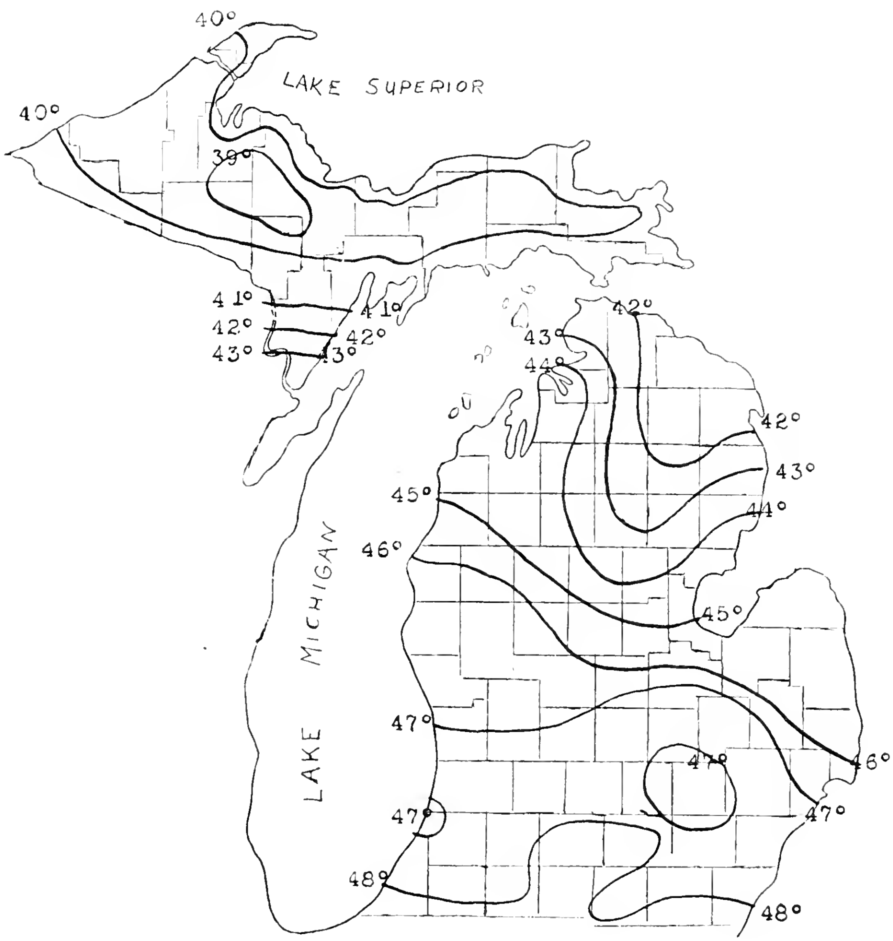

CHART II.-Mean temperature for the year in degrees Fahrenheit. (Average for ten or more years.

Charts III and IV, showing the mean temperature of Michigan for January and July, respectively, show the lake effect more clearly. In the former the lines bend sharply northward along Lake Michigan, as the temperature is higher on the lake shore. In the Lake Superior region the isotherms parallel the shore line, the temperature of the coast cities being four to six degrees warmer than interior points but a few miles distant. Just the opposite conditions are shown on the chart for July. Here the lines bend sharply downward along the Lake Michigan shore, the temperature being as low at South Haven, for example, as at West Branch, an interior station more than 100 miles farther north.

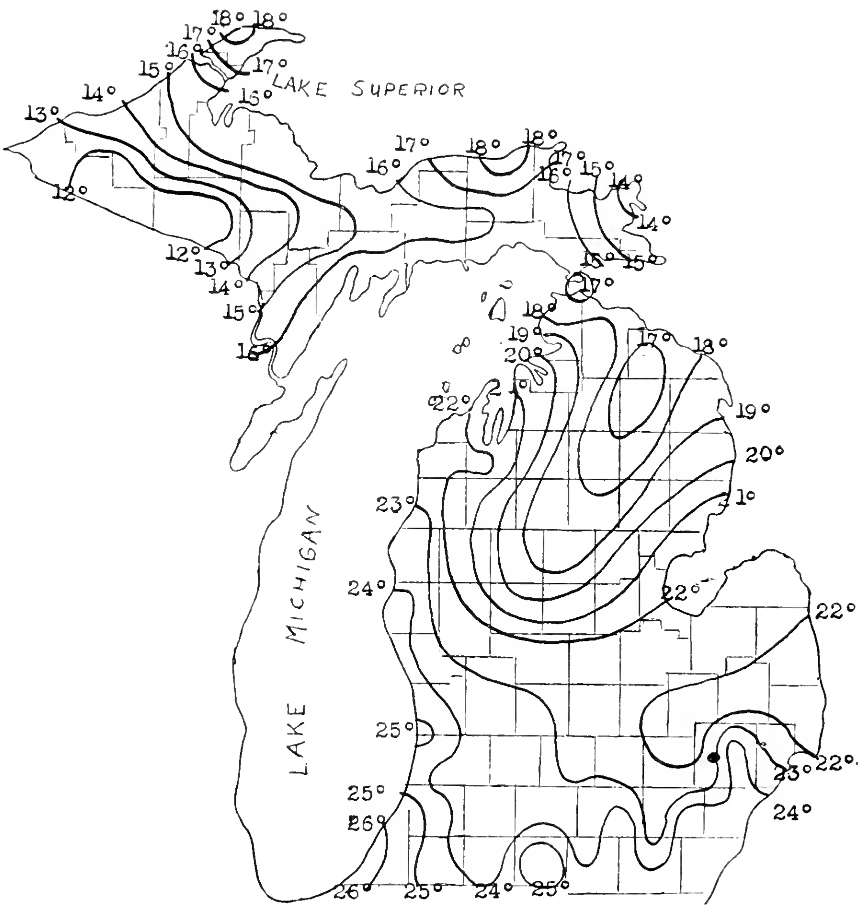

CHART III.-Mean temperature for the month of January.

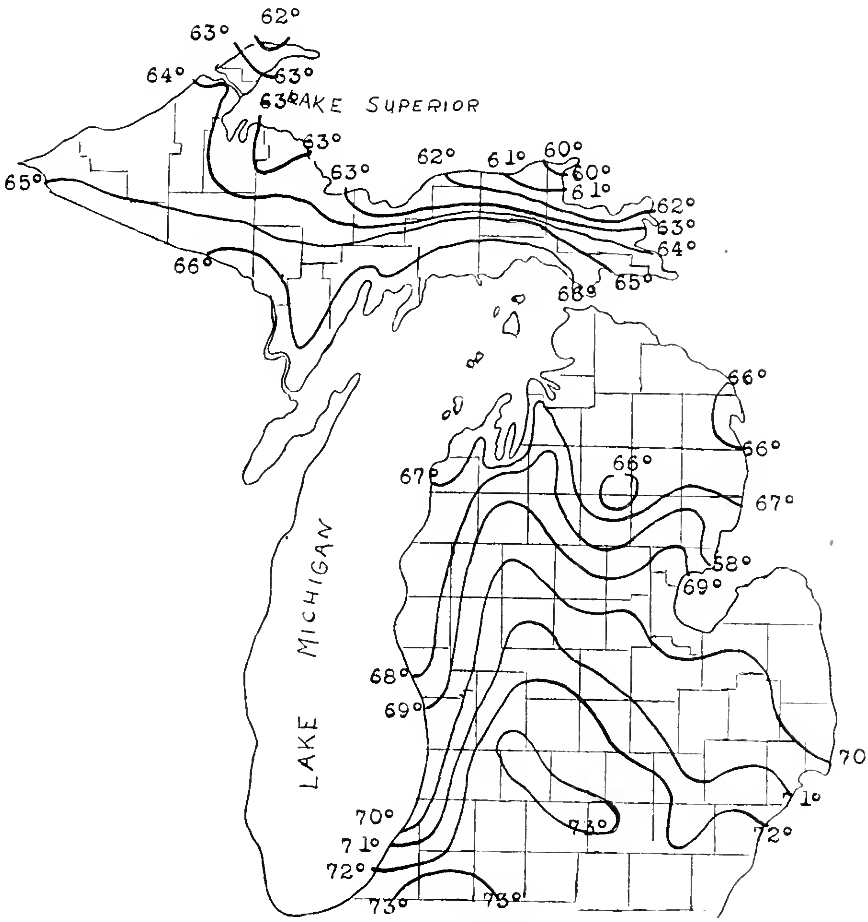

CHART IV.-Mean temperature for the month of July.

The most striking illustration of the lake effect is brought out by Charts V and VI. These charts are drawn from data recorded during the very cold month of January, 1912, and the very hot month of July, 1916, the temperatures used, being respectively, the lowest in January and the highest in July. The moderating effect of all the lakes is shown by Chart V. In the upper peninsula readings as low as -45° F. and -46° F. were registered in the interior counties, while at Eagle Harbor the north-most station, on the Keweenaw peninsula, the lowest reached was -17° F. In the lower peninsula -39° F. was recorded at Gaylord, Otsego county, but the lowest at Old Mission, on Grand Traverse Bay, at the same latitude was -7° F.

The July maximum temperature chart, (Chart VI), brings out the cooling effect of the lakes, especially Lake Michigan during extremely hot weather. Here the isotherms are crowded close together, parallel

to the shore line, indicating a rapid rise as one leaves the lake. The highest temperature recorded during this month of almost unprecedented heat, ranged from 93 to 96° F. on the lake shore, to as high as 105 and 106° F. in the interior of the lower peninsula. The hot southwest winds in traversing Lake Michigan were cooled 10° or more. On the Lake Superior shore, however, temperatures were as high or even higher, than further inland, because the winds were southwesterly and the lake effect was not felt, while inland the greater elevation of the land tended to reduce the temperature somewhat.

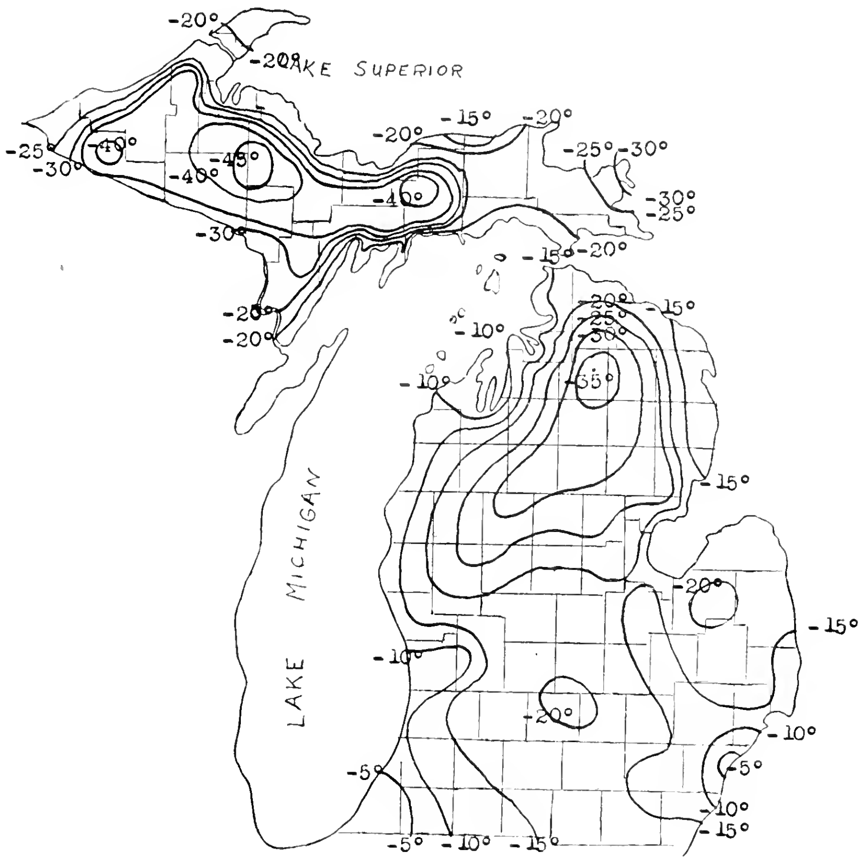

CHART V.-Lowest temperatures recorded during January, 1912, one of the coldest months on record in Michigan.

To further illustrate the effect of the Great Lakes on temperature five tables are reproduced, herewith, as follows: The mean monthly temperature, mean monthly maxium temperature, mean monthly minimum temperature, absolute maximum and absolute minimum temperatures at Grand Haven, Michigan, Milwaukee, Wis., and the average of such temperatures at five cities in South Dakota, Wisconsin and Iowa,

having the same latitude, as compiled by Eshleman (1). The difference in temperature between that at Grand Haven and the average of the five interior stations is noted by means of "+" and "—" signs. It will be noted from Table II that the mean temperature for the year is practically the same for all stations, but that Grand Haven is warmer in winter and colder in summer by several degrees than the western stations, and slightly warmer in winter and cooler in summer than Milwaukee, be-

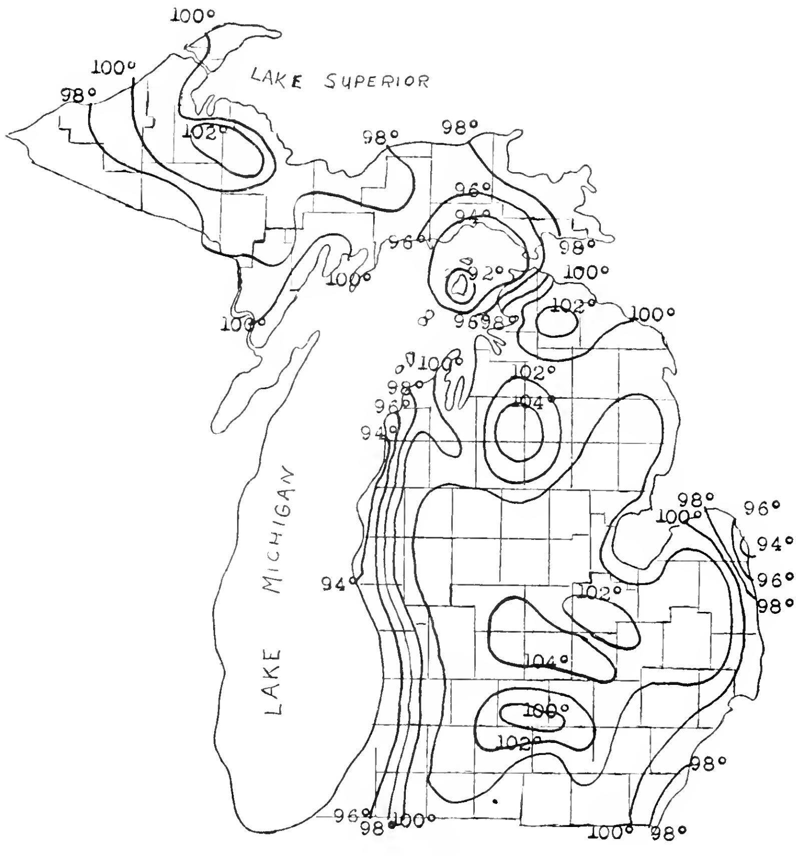

CHART VI.-The highest temperature recorded during July, 1916, one of the warmest months on record.

cause it is on the windward side of the lake. Table III gives the average maximum temperature for each month at the several stations and shows a great difference between Grand Haven and the western cities during the summer months, also in the spring and early autumn, Grand Haven being cooler during this period by 6 to 10° F. The average minimum temperatures reached daily for the various months are tabulated in Table IV, bringing out the fact that extreme cold is not felt at Grand Haven as it is in the west, away from the lake. Throughout the winter

the difference ranges from 9° F. to 11° F. But the most pronounced effects are shown in Tables V and VI which give the highest and lowest ever recorded, respectively, each month in the year.

TABLE II.—MEAN MONTHLY TEMPERATURE (°F.)

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Grand Haven......	24	24	31	44	55	65	70	68	61	50	38	30	46
Milwaukee.........	20	22	32	43	51	64	70	69	62	50	36	26	46
Western Stations...	18	17	32	48	59	68	73	71	62	50	33	22	46
Difference.........	+6	+7	−1	−4	−4	−3	−3	−3	−1	0	+5	+8	0

TABLE III.—MEAN MONTHLY MAXIMUM TEMPERATURE (°F.)

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Grand Haven......	31	29	39	52	63	73	77	76	70	58	45	34	54
Milwaukee.........	27	30	38	52	63	72	78	76	70	58	43	32	56
Western Stations...	29	28	43	61	73	81	87	85	76	64	44	32	53
Difference.........	+2	+1	−4	−9	−10	−8	−10	−9	−6	−6	+1	+2	−5

TABLE IV.—MEAN MONTHLY MINIMUM TEMPERATURE (°F.)

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Grand Haven......	19	16	25	36	45	56	60	59	53	43	32	24	39
Milwaukee.........	13	15	24	37	45	55	62	61	54	44	30	20	38
Western Stations...	9	7	21	36	47	57	61	59	50	38	22	13	35
Difference.........	+10	+9	+4	0	−2	−1	−1	0	+3	+5	+10	+11	+4

TABLE V.—ABSOLUTE MAXIMUM TEMPERATURE (°F.)

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Grand Haven......	61	59	71	84	92	92	92	92	82	82	72	61	94
Milwaukee.........	61	60	81	86	94	98	100	98	95	88	73	63	100
Western Stations...	63	72	84	95	98	104	110	104	103	92	75	65	110
Difference.........	−2	−13	−13	−11	−11	−12	−16	−12	−11	−10	−3	−4	−16

TABLE VI.—ABSOLUTE MINIMUM TEMPERATURE (°F.)

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov	Dec.	Year
Grand Haven	−14	−25	−5	9	28	37	40	42	30	20	0	−12	−25
Milwaukee	−25	−24	−8	12	25	38	47	42	30	15	−14	−22	−25
Western Stations	−30	−32	−12	9	28	35	40	37	20	7	−13	−24	−32
Difference	+16	+7	+7	0	0	+2	0	+5	+10	+13	+13	+12	+7

The tables above show the effect of Lake Michigan on the temperature of Grand Haven and Milwaukee. The average of five stations in South Dakota, Wisconsin and Iowa, having the same latitude as Grand Haven and Milwaukee, were selected for comparison. The "difference" is the departure between the reading at Grand Haven and the average of the five western stations, in each case.

These tables show that the extremes of temperature experienced at inland stations are not felt at Grand Haven, which is a typical lake station.

As already stated the frequent passage of cyclones and anti-cyclones across the lake region causes fluctuating temperature to a greater extent than is found in regions outside the storm path. In the winter season the approach of a storm area from the west is preceded by southerly wind and rising temperature in Michigan, and the high pressure area which follows brings with it a shift of wind to the northwest, with colder weather. In the summer season storm areas which move across the northern portion of the Great Lakes, at a time when the pressure is high over the southeastern states, cause hot waves in this state, but these are usually followed in a day or two by refreshing northerly breezes attending approaching high pressure areas from western Canada. The changeableness of the temperature is therefore one of the noticeable features of the climate of Michigan.

PRECIPITATION.

Rain and snowfall should be next considered. The same four factors which control the temperature of a place also influence, to a greater or less extent, the amount of precipitation. The influence of latitude is not so pronounced on precipitation as on temperature. In fact within the range of latitude found in Michigan no difference in rainfall due to distance from the equator is noticeable.

The effect of elevation is noticeable, however, perhaps to a greater extent than on temperature. Chart VII, showing the normal precipitation for the year over the state, if noted in connection with Chart I, giving elevations, reveals the fact that rainfall usually increases with altitude as a general rule. This is especially true on the western slope of higher land. For example the heaviest rainfall in the state is in the southern tier of counties, beginning about 25 miles from the lake, where the elevation begins to increase toward the eastward. In the upper peninsula the most rain falls in the interior counties, where the elevation is greatest. In the elevated regions in the northern portion of the lower peninsula, however, the rainfall is not greater than nearby sections having less altitude.

The Great Lakes undoubtedly increase the rainfall throughout this whole region, but the annual amount of precipitation is not noticeably

greater on the immediate lake shores than further inland. Such large bodies of water furnish much vapor to the atmosphere, which is carried upward by convection with each cyclone which passes, is cooled, condensed and precipitated as rain or snow. In the lake region the annual rainfall is over thirty inches, while in the Dakotas it is less than twenty inches,—a difference due partly, at least, to the lake effect. The reason

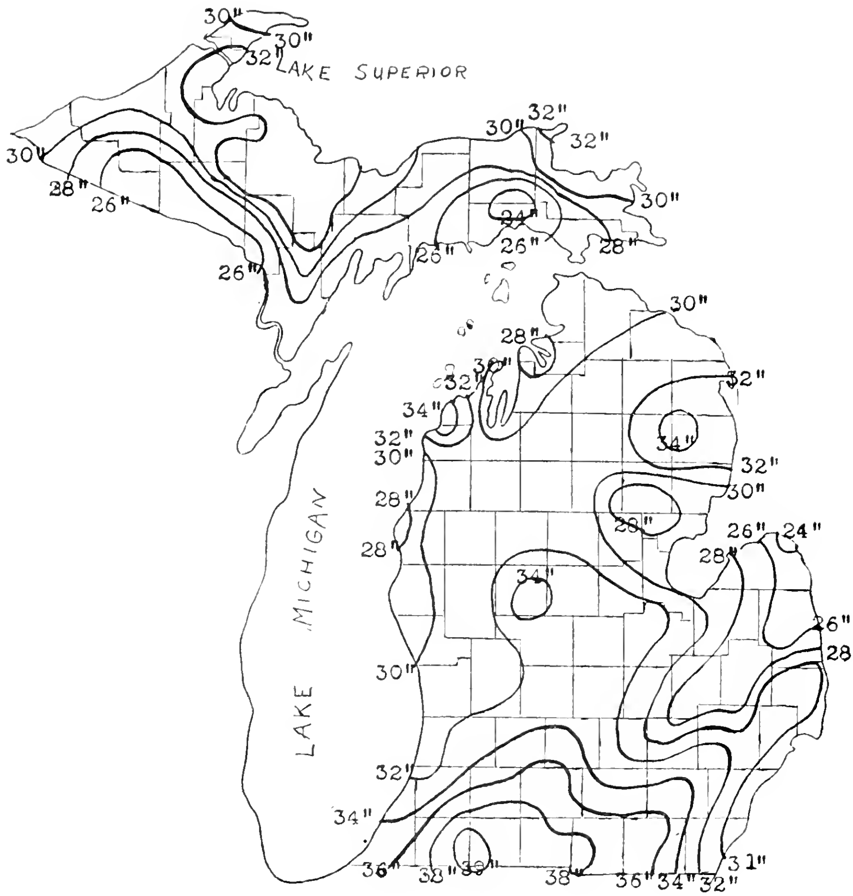

CHART VII.-Average annual rainfall in inches.

for even less rainfall immediately along the shores of the lakes, than in some interior sections, may be the fact that the cooler weather near the lakes in summer does not foster the convectional action and local thunderstorms to the extent that the warmer interior regions do. The average number of thunderstorms per year at Grand Haven, Mich., is twenty-six, while at Lansing the average is forty-two. The snowfall is considerably greater near the lakes, however, especially along the southern coast of Lake Superior and the eastern coast of Lake Michigan. In the former section over one hundred inches of snow usually falls each

winter, as shown in Chart VIII. Along the shore of Lake Michigan from fifty to sixty inches per year is the average, but in the interior of the state the snowfall totals from thirty to fifty inches annually, in most sections. In the southern portion of the upper peninsula the snowfall is less than fifty inches. This heavy snowfall along the lakes is caused by the passage of the prevailing westerly winds, first over the compara-

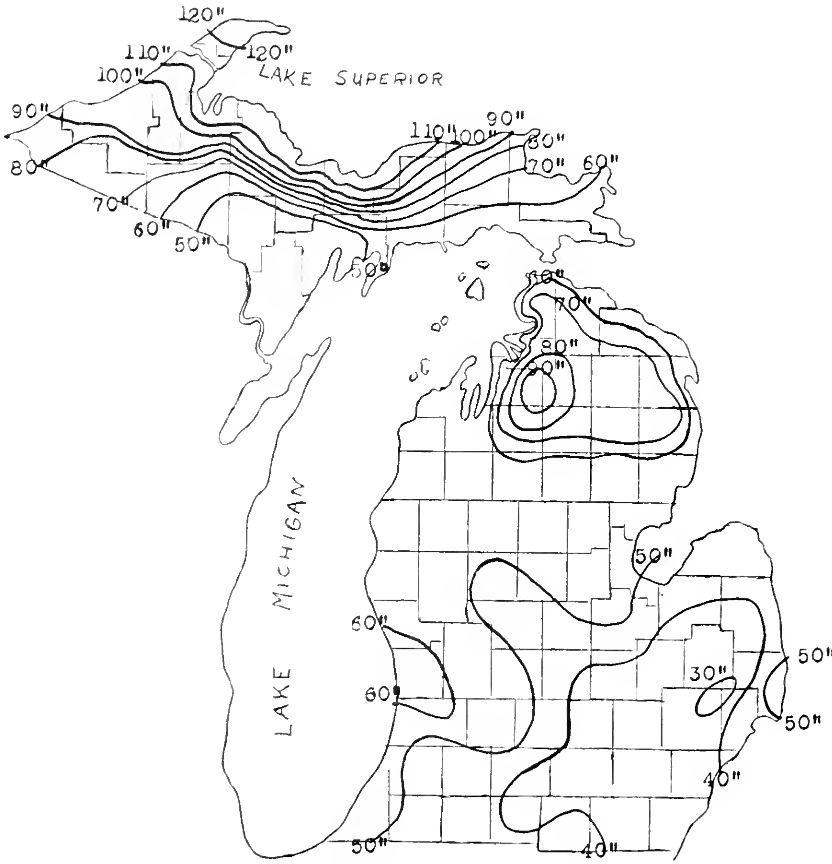

CHART VIII. -Average annual snowfall, in inches.

tively warm water of Lakes Michigan and Superior, for distances of sixty to over one hundred miles, causing them to become moisture laden, and then on coming in contact with the cold land areas along the shore the moisture is condensed and falls as snow almost continually, at least while the winds continue on shore, during the winter season. The ground is usually covered in the Lake Superior region, with one to five feet of snow, from middle autumn to late spring.

The fourth factor controlling climate, i. e., the proximity of the normal storm path, is a very important one as regards rainfall. Ordinarily each successive low pressure area brings more or less rain or snow as it

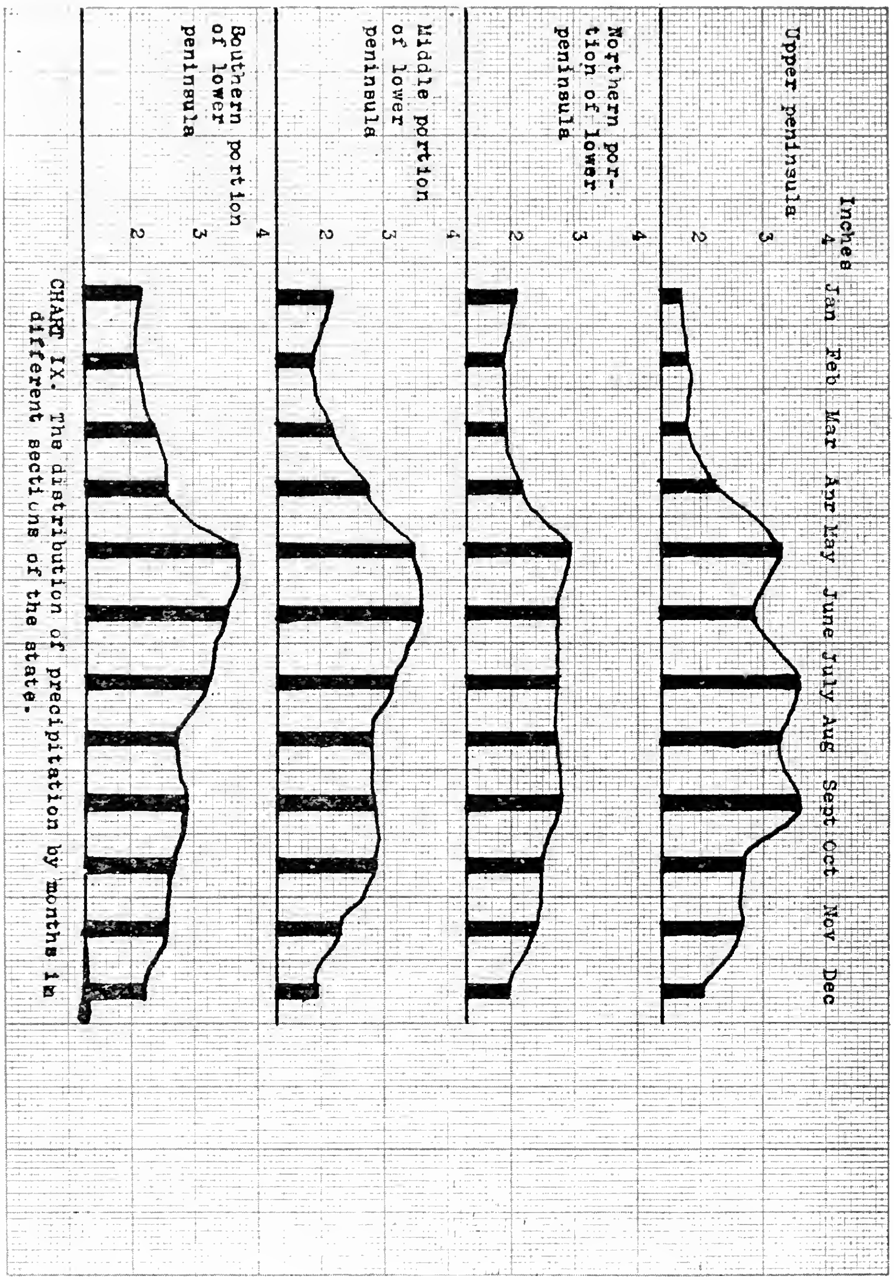

CHART IX. The distribution of precipitation by months in different sections of the state.

passes over Michigan, and the precipitation is therefore ample and well distributed through the year. Chart IX brings out this matter of distribution in different portions of the state, as well as graphically showing the amount of rainfall available in each place.

CLOUDINESS.

The amount of sunshine is an important element in climate both on account of its relation to crop growth and development and the general welfare and happiness of mankind. It probably ranks next after temperature and precipitation, in importance.

Like precipitation the range of latitude found in Michigan has no appreciable affect on the amount of cloudiness, but on account of the fact that the possible hours of sunshine increases, during the summer season, with distance from the equator, the fact should be noted that the days are more than thirty minutes longer in summer, in the upper peninsula, than in the southern portion of the lower peninsula.

The range of elevation in Michigan is hardly sufficient to cause an appreciable difference in the amount of cloudiness but the influence of the Great Lakes is decided. As was explained in connection with the discussion of precipitation, the warm, moist air over the Lakes in winter, is carried land-ward by the prevailing westerly winds, and clouds are continuously formed, by condensation, when the colder land areas are reached. The weather is therefore unusually cloudy in Michigan during the late fall and winter months, especially in the western half of the lower peninsula. In fact with the exception of portions of New York state, along the eastern end of Lake Erie, and in the eastern portion of the upper peninsula of Michigan, there is less sunshine along the Lake Michigan shore than in any other section of the country. In January the actual sunshine in western Michigan is less than twenty per cent of the possible amount.

During the warmer portions of the year, however, the Great Lakes have just the opposite effect. The cool water tends to prevent convection and clouds are not formed to the extent that they are in warmer sections. As a result the amount of sunshine is greater in July, by about ten per cent, in western Michigan then it is in Ohio and Indiana.

The alternate passage of areas of high and low pressure over the state results in fluctuating cloudiness. Low areas usually cause more or less cloudiness for one or two days during their approach and passage and these are followed by two or three days of clear weather, as the anti-cyclones pass over. This change from cloudy to clear weather and back again is not noticeable in the winter season to the extent that it is in summer on account of the almost continuous cloudiness caused by the lakes. In the summer time the cyclonic and anti-cyclonic formations often become so feeble that they fail to cause the normal changes in cloudiness and there are long periods of uninterrupted sunshine.

WIND.

The wind direction and velocity are important largely on account of their relation to the other climatic elements. The direction of the pre-prevailing winds, for example, is especially important in this state on account of the position of the Great Lakes. If the prevailing wind were

east instead of west then it would be the Lake Huron shore that would have the more equable climate.

Michigan is, of course, in the region of the prevailing westerly winds. Chart X shows the prevailing direction at each observing station in the state. Local influences such as the contour of the land and the proximity of the Lakes cause a deviation from the true west, at some stations. The "land and sea breeze" is pronounced along the lake shores. This is a local wind, blowing on shore in the heat of the day and toward the water at night, due to convection. The air becomes hot and lighter over the land than over the water on a hot summer day, and the cooler and heavier air over the cool water moves in, forcing it upward. Just the opposite action takes place at night, when the land becomes cooler than the lake. These cool, refreshing lake breezes are very welcome on a hot summer afternoon, but in the early spring they are often too cool to be pleasant. The temperature often falls thirty degrees or more within a few minutes when the wind shifts, on a warm spring afternoon.

TABLE VII.—This table shows the number of rainy, clear, partly cloudy and cloudy days in each month and for the year in each of four sections of the state. A "Rainy" day is one with 0.01 inches or more of rain or melted snowfall, a clear day is one with zero to three-tenths clouds, a partly cloudy day, four to seven-tenths of clouds, and a cloudy day eight to ten-tenths overcast.

Days	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Upper peninsula:													
Rainy	10	8	8	8	11	9	8	8	10	9	10	10	109
Clear	8	10	12	13	13	14	17	15	12	11	8	7	140
Partly cloudy	5	6	7	6	7	7	8	8	7	6	6	6	79
Cloudy	18	12	12	11	11	9	6	8	11	14	16	18	146
Northern portion of lower peninsula:													
Rainy	9	8	8	8	8	7	7	7	8	8	7	8	93
Clear	7	9	11	12	14	14	17	15	12	13	8	6	138
Partly cloudy	6	7	8	7	8	9	8	9	8	7	7	6	90
Cloudy	18	12	12	11	9	7	6	7	10	11	15	19	137
Central portion of lower peninsula:													
Rainy	9	7	7	8	9	8	8	7	8	7	7	8	93
Clear	6	7	9	10	10	13	15	15	12	12	7	5	121
Partly cloudy	9	9	10	9	12	11	11	11	10	9	9	9	119
Cloudy	16	12	12	11	9	6	5	5	8	10	14	17	125
Southern portion of lower peninsula:													
Rainy	10	7	9	9	10	9	8	8	8	7	7	9	101
Clear	7	8	9	11	12	13	16	15	14	13	9	7	134
Partly cloudy	6	8	9	8	9	10	10	10	10	8	8	7	101
Cloudy	18	12	13	11	10	7	5	6	8	10	13	17	130

As has already been stated the passage of areas of low and high pressure across the Great Lakes region is attended by shifting winds. The currents of air flow spirally inward toward the centers of low barometer, counter-clockwise, while in the high pressure areas the winds blow spirally outward from the center, in a clockwise direction. When a cyclone approaches from the west, therefore, the winds are first southeasterly, shifting around either through east and north, or through south and southwest, depending, of course, on the path the storm takes, changing in the former direction if the storm passes south of the observer, and in the latter direction if the center is to the northward.

With the oncoming high area, if it advances from the northwest, the winds are northwesterly. With a good aneroid barometer and wind vane the movement and passage of these atmospheric formations can be determined and followed with interest and profit, for they largely control weather changes.

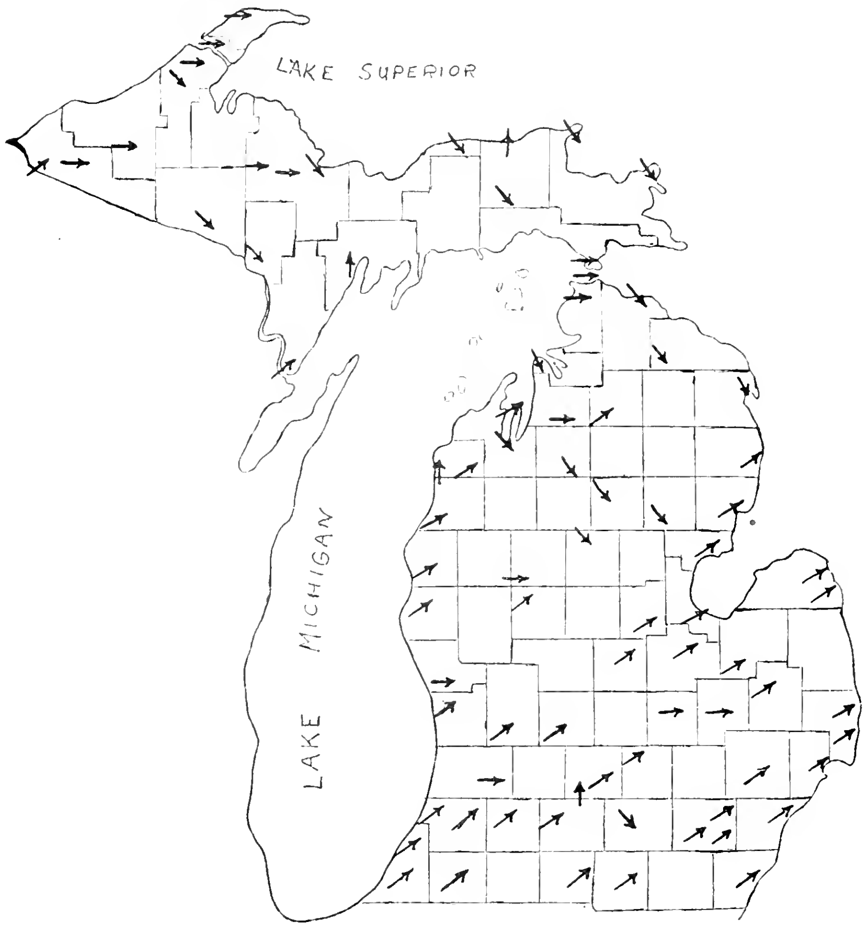

CHART X.-Prevailing wind direction. Arrow' fly with the wind.

HUMIDITY.

The amount of moisture in the atmosphere in the form of vapor is important enough to be classed in with the other climatic elements. It is usually expressed in terms of relative humidity, or the per cent of moisture present in the air, compared with the possible amount. The capacity of the air for moisture increases rapidly with the temperature. For example the invisible vapor necessary to saturate air at 40° F. is

sufficient to produce a relative humidity of but 50 per cent when the air temperature is increased to 60° F.

Of the four factors which control climate only the last two need to be mentioned here in their relation to humidity, because neither the range of latitude or altitude found in Michigan is sufficient to appreciably change the humidity. But the presence of the large water surfaces of the Great Lakes is an important factor in influencing the humidity, because such surfaces are constantly evaporating water into the atmosphere. The following table will serve to show the effect of the Great Lakes on relative humidity:

TABLE VIII.—RELATIVE HUMIDITY AT LANSING, MICH., AND BISMARCK, N. D. AT 7 P. M., BY MONTHS AND FOR THE YEAR.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Lansing, Mich.....	85	80	74	68	68	68	67	73	80	81	80	85	76
Bismarck, N. D....	66	67	65	55	54	59	52	49	52	60	63	67	59

Part of the difference in relative humidity between the two stations in the table is probably due to the fact that Bismarck, N. D., is some distance from the normal storm path, while Lansing, Michigan is more directly in the region most frequently traversed by "highs" and "lows." An increase in cloudiness and rainfall, brought about by the passage of low pressure areas, also causes an increase in relative humidity.

OTHER PHENOMENA.

There is yet to be considered the occurrence of other atmospheric phenomena such as hail, frost, tornadoes, etc. These are more or less destructive to farm crops and their discussion will properly fall in what is to follow. But a word should be said as to their distribution and frequency over the state before the subject of the relation between the climate of Michigan and agriculture is taken up.

Hail is attendant upon heavy thunderstorms. It is very local in character, covering only small areas in any particular storm. On the average two hailstorms per year occur at Lansing, which may be considered a typical station for Michigan, but the number is less near the lake shores.

Frosts occur each fall and spring, the dates being largely influenced by the first three factors, influencing climate, i. e., latitude, altitude, and proximity of the lakes. The fourth factor should also be considered but somewhat modified. Latitude of course is an important factor in determining how late in the spring and early in the fall killing frosts are liable to occur. In the interior of the upper peninsula the weather remains cold until early summer and the period of warm weather is short, while in the extreme southern portion of the state it is much warmer. A table is appended giving the dates of frost and the length of the growing season at many stations in the state. From this table the following is extracted to illustrate the matter of the effect of latitude on dates of frost:

	Stations	
	Humboldt	Adrian
Latitude	46° 30′	41° 50′
Average date last killing frost in spring	June 11	May 7
Average date first killing frost in fall	Aug. 27	Oct. 25
Average length of growing season	77 days	171 days

Elevation has some bearing on the length of the growing season, but the matter of air drainage as affected by local influences is more important. A station on a hillside, which allows the cold air to drain off into a valley below, will escape frosts longer than a place situated at a lesser altitude.

The proximity of the lakes has a pronounced influence in preventing early frosts in the fall. At Frankfort, on Lake Michigan, the average date of the first killing frost in autumn is October 19, while at Grayling, about the same distance north, but in the interior of the state the average fall frost is more than a month earlier. Table IX and Charts XI, XII and XIII show the dates of frost and length of the growing season.

TABLE IX.—DATES OF KILLING FROST AND LENGTH OF GROWING SEASON.

UPPER PENINSULA.

Station	County	Latest date of killing frost in spring	Earliest date of killing frost in autumn	Average date last killing frost in spring	Average date first killing frost in autumn	Average length of the growing season in days
Baraga	Baraga	June 27	Aug. 2	May 25	Sept. 5	103
Calumet	Houghton	May 30	Aug. 26	May 17	Oct. 1	137
Chatham	Alger	June 28	July 16	June 13	Sept. 6	85
E. Harbor	Keweenaw	June 7	Sept. 13	May 23	Oct. 10	140
Escanaba	Delta	July 9	July 21	May 13	Oct. 5	145
Grand Marais	Alger	June 1	Sept. 12	May 17	Oct. 10	146
Houghton	Houghton	May 27	Sept. 22	May 12	Oct. 10	151
Humboldt	Marquette	June 28	July 16	June 11	Aug. 27	77
Iron Mountain	Dickinson	June 15	Aug 27	May 20	Sept. 25	128
Ironwood	Gogebic	June 13	Sept. 1	May 22	Sept. 24	125
Iron River	Iron	July 23	July 23	June 8	Sept. 9	93
Ishpeming	Marquette	June 18	July 26	June 1	Sept. 17	107
Mackinac Island		June 20	Sept. 21	May 18	Oct. 11	146
Maple Ridge	Delta	June 27	Aug. 27	June 5	Sept. 11	98
Marquette	Marquette	June 11	Aug. 22	May 13	Oct. 7	147
Menominee	Menominee	June 21	Sept. 16	May 13	Oct. 10	150
Newberry	Luce	June 20	Aug. 27	May 28	Sept. 19	105
St. Ignace	Mackinac	June 28	Sept. 1	May 13	Oct. 6	146
Sault Ste. Marie	Chippewa	May 28	Sept. 14	May 13	Oct. 2	142
Whitefish Point	Chippewa	May 28	Sept. 21	May 20	Oct. 13	146

TABLE IX. *Concluded.*

NORTHERN COUNTIES, LOWER PENINSULA.

Station	County	Latest date of killing frost in spring	Earliest date of killing frost in autumn	Average date last killing frost in spring	Average date first killing frost in autumn	Average length of the growing season in days
Alpena	Alpena	June 9	Sept. 6	May 13	Sept. 30	146
Benzonia	Benzie	May 27	Aug. 27	May 13	Oct. 5	145
Charlevoix	Charlevoix	June 10	Aug. 27	May 14	Oct. 12	151
Cheboygan	Cheboygan	June 20	Aug. 26	May 22	Sept. 24	125
East Tawas	Iosco	June 24	Aug. 22	May 20	Sept. 27	131
Frankfort	Benzie	May 27	Sept. 29	May 10	Oct. 19	162
Grayling	Crawford	June 8	Aug. 26	May 20	Sept. 18	121
Harrison	Clare	May 30	Aug. 27	May 14	Sept. 29	138
Harrisville	Alcona	June 20	Sept. 4	May 17	Oct. 3	139
Ivan	Otsego	June 12	Aug. 26	May 23	Sept. 25	140
Ludington	Mason	June 17	Sept. 17	May 14	Oct. 8	144
Mackinaw	Cheboygan	June 20	Aug. 26	May 20	Oct. 4	137
Mancelona	Antrim	July 13	Aug. 26	May 28	Sept. 22	117
Manistee	Manistee	May 28	Sept. 29	May 10	Oct. 10	153
Old Mission	Grand Traverse	June 9	Sept. 29	May 13	Oct. 20	160
Omer	Arenac	June 12	Aug. 18	May 25	Sept. 21	119
Onaway	Presque Isle	June 14	Sept. 3	May 27	Sept. 22	121
Reed City	Osceola	June 17	Aug. 23	May 22	Sept. 23	124
Roscommon	Roscommon	June 25	Aug. 21	June 14	Sept. 12	90
St. James	Charlevoix	June 9	Sept. 25	May 16	Oct. 12	149
Traverse City	Grand Traverse	May 31	Sept. 17	May 16	Oct. 6	143
West Branch	Ogemaw	June 24	Aug. 27	May 25	Sept. 26	124

CENTRAL COUNTIES, LOWER PENINSULA.

Station	County	Latest date of killing frost in spring	Earliest date of killing frost in autumn	Average date last killing frost in spring	Average date first killing frost in autumn	Average length of the growing season in days
Alma	Gratiot	May 28	Sept. 2	May 12	Sept. 29	140
Arbela	Tuscola	June 9	Aug. 27	May 12	Sept. 23	134
Bay City	Bay	May 28	Sept. 18	May 9	Oct. 12	157
Big Rapids	Mecosta	May 29	Sept. 2	May 13	Sept. 23	133
Harbor Beach	Huron	June 4	Sept. 17	May 11	Oct. 8	150
Hart	Oceana	May 28	Sept. 2	May 13	Oct. 8	148
Muskegon	Muskegon	May 27	Sept. 14	May 7	Oct. 8	142
Port Austin	Huron	June 20	Sept. 10	May 16	Oct. 3	140
Saginaw	Saginaw	May 28	Sept. 14	May 5	Oct. 7	155

SOUTHERN COUNTIES, LOWER PENINSULA.

Station	County	Latest date of killing frost in spring	Earliest date of killing frost in autumn	Average date last killing frost in spring	Average date first killing frost in autumn	Average length of the growing season in days
Adrian	Lenawee	May 28	Sept. 19	May 7	Oct. 25	171
Allegan	Allegan	June 11	Sept. 5	May 13	Oct. 9	149
Ann Arbor	Washtenaw	May 14	Sept. 22	May 4	Oct. 16	165
Battle Creek	Calhoun	May 27	Sept. 19	May 3	Oct. 9	159
Bloomingdale	Van Buren	May 27	Sept. 12	May 8	Oct. 10	155
Cassopolis	Cass	May 27	Sept. 22	May 3	Oct. 13	163
Coldwater	Branch	May 21	Sept. 18	May 3	Oct. 6	156
Detroit	Wayne	May 31	Sept. 22	Apr. 29	Oct. 13	167
Eloise	Wayne	May 27	Sept. 18	May 8	Oct. 9	154
Flint	Genesee	May 27	Sept. 18	May 9	Oct. 7	151
Grape	Monroe	May 28	Sept. 19	May 7	Oct. 13	159
Hastings	Barry	May 28	Sept. 18	May 15	Oct. 4	142
Hillsdale	Hillsdale	May 28	Sept. 19	May 10	Oct. 6	149
Holland	Ottawa	May 27	Sept. 26	May 9	Oct. 9	153
Howell	Livingston	May 28	Sept. 19	May 8	Oct. 7	152
Jackson	Jackson	May 21	Sept. 18	May 3	Oct. 10	160
Jeddo	St. Clair	May 28	Sept. 22	May 7	Oct. 15	161
Lansing	Ingham	May 28	Sept. 19	May 4	Oct. 9	158
Mt. Clemens	Macomb	May 31	Sept. 19	May 13	Oct. 10	150
Owosso	Shiawassee	June 8	Sept. 14	May 13	Oct. 4	146
Plymouth	Wayne	May 28	Sept. 2	May 7	Oct. 3	149
Pontiac	Oakland	May 29	Sept. 11	May 11	Oct. 10	152
Port Huron	St. Clair	June 6	Sept. 22	May 6	Oct. 10	157
South Haven	Van Buren	May 20	Sept. 21	May 3	Oct. 13	163
Ypsilanti	Washtenaw	May 29	Sept. 14	May 10	Oct. 6	149

Tornadoes occur infrequently in Michigan, on the average about one or two per year in the entire state. They are practically unknown in the upper peninsula. The region of most frequent occurrence is in the south-central portion of the state. The Great Lakes undoubtedly decrease the number somewhat, on account of their cooling effect, thereby checking the required convection. These destructive local storms occur usually in the southeastern portion of the larger disturbance, or cyclone, and as the state is in the path of greatest frequency of these cyclones, it

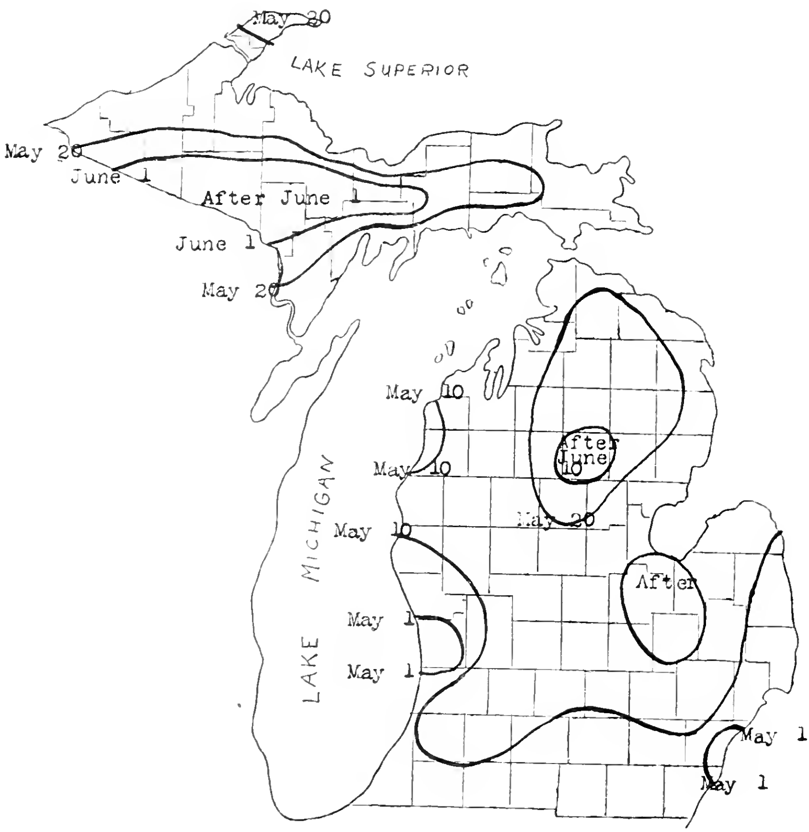

CHART XI.-Average date of last killing frost in Spring

seems reasonable to suppose that tornadoes would be more frequent in Michigan than in other states outside the path of storms, were it not for the Great Lakes.

Notable tornadoes, in recent years, were two which occurred in 1911 and 1915 respectively. The first passed through the city of Owosso, doing considerable damage and causing some loss of life. The second passed southwestward from the city limits of Charlotte, Mich., passing two miles north of Eaton Rapids, to some inland lakes southeast of Stockbridge, Mich., where it disappeared. This storm was of unusual severity

and leveled everything in its path. Had it passed through any city it would have caused great loss of life and greater destruction to property.

High winds occur at intervals in connection with thunderstorms, of sufficient strength to do serious damage, but the state is still fairly well wooded and sufficiently rolling to check the wind velocity to a considerable extent. High winds are frequent on the Great Lakes, in connection with marked cyclonic formations, but their velocity is lessened as they come inland.

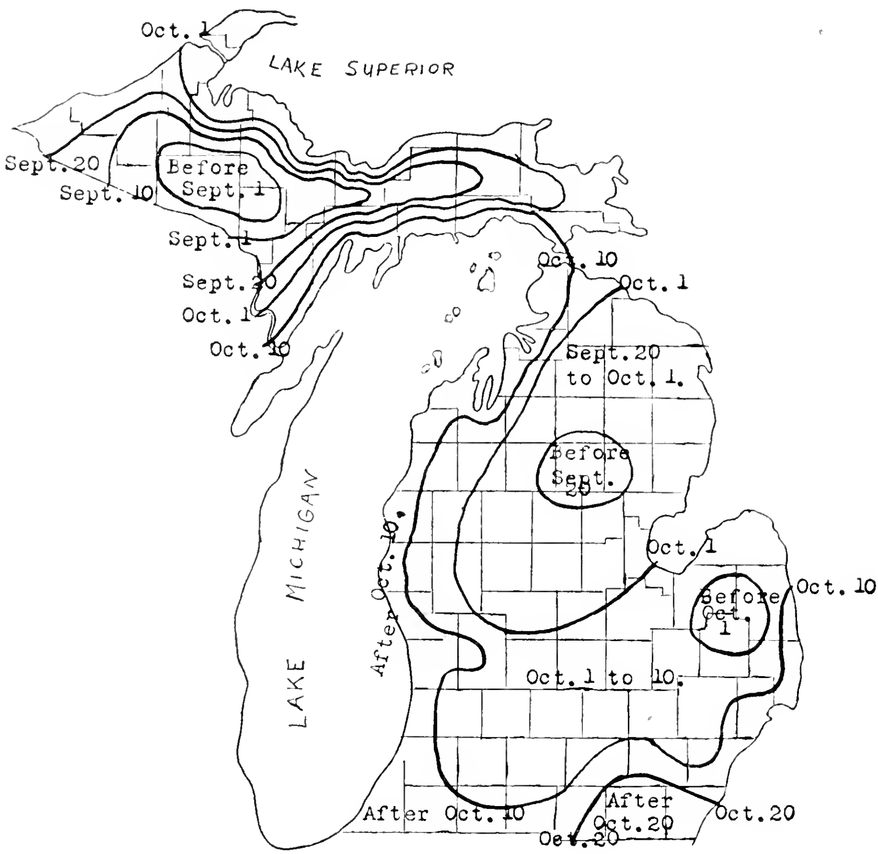

CHART XII.-Average date of the first killing frost in autumn.

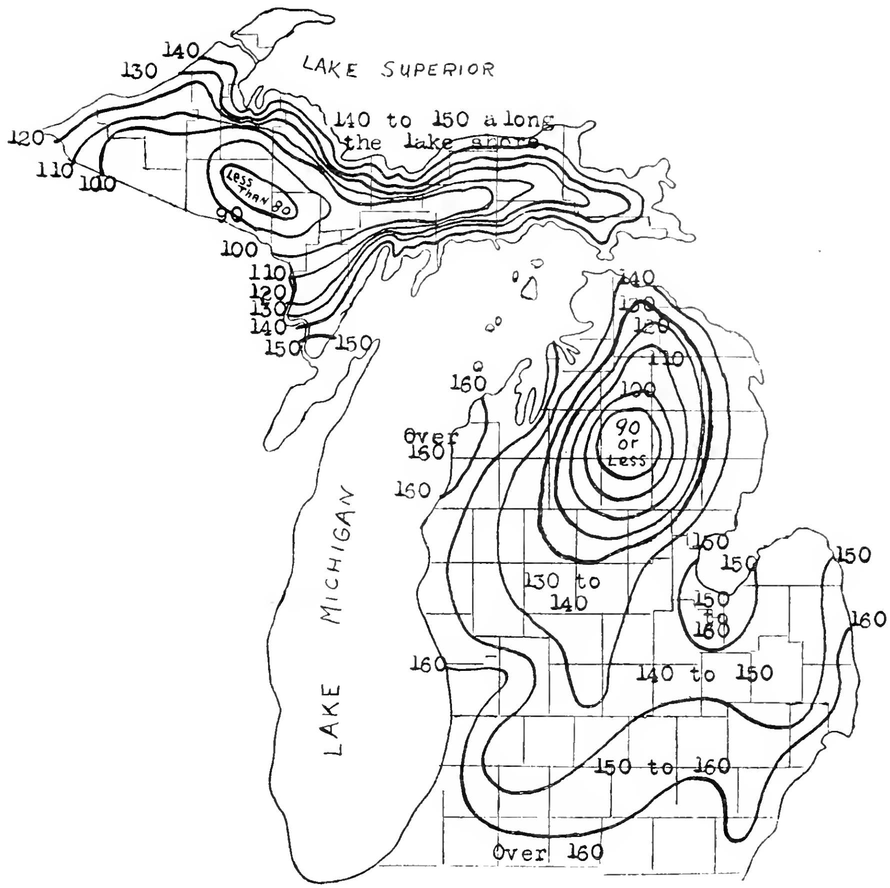

CHART XIII.-Length of growing season, in days.

PART III.

THE RELATION OF THE CLIMATE OF MICHIGAN TO AGRICULTURE.

Climate and agriculture are closely related because all crops require certain amounts of heat, moisture and sunshine to make normal growths. The exact requirements of any crop for any given climatic condition are very difficult to determine and state in figures, because the relationship is complicated and plants are able in a measure to overcome unfavorable environment. Probably no exact statement has yet been made as to the most favorable temperature conditions, for example, under which a crop would thrive best, or how many heat units are necessary for any crop plant to perform its life functions to the best advantage. There have been numerous attempts to find a "thermal constant," as it has

been called, for various crops, in terms of air temperature during the life phase of any crop, under the supposition that a uniform quantity of heat is necessary to produce a given increase in growth. But widely different results are found from year to year when daily air temperatures are added together over a period during which the plant is passing through a certain growth stage. Somewhat closer results are obtained by subtracting a constant amount, usually 42, from each air temperature considered, because 42° F. may be taken as zero for plant growth for ordinary farm crops. This process of adding together the remainders after subtracting 42 from each daily temperature reading, has been called the "summation method" of studying the relation between air temperature and plant growth. As stated above it does not give consistent results.

Livingston,[2] Lerenbauer,[3] and others have introduced Van't Hoff's law into the problem, to the effect that chemical action, and hence plant growth, which is largely chemical in nature, is accelerated and doubled with each increase of 18° F. in temperature. This system seems to hold good for medium temperatures, and gives closer results than the summation process, but it fails, as does the latter also, when higher temperatures are concerned, because it takes no account of the fact that the rate of growth decreases after a certain temperature is passed.

To overcome this defect and to further perfect the system, Livingston[4] has worked out a series of values or indices of growth corresponding to each degree of temperature. These indices were determined from Lerenbaurer's[5] curve of growth in maize seedlings as controlled by temperature. He took the rate of growth at 40° F. as unity and found value for each succeeding temperature on this basis. The highest value was 122 at 89° F., after which the indices rapidly decreased to unity again at 116° F. When this system is applied to air temperatures it gives slightly better results for the earlier growth phases, but seems to be no improvement over earlier methods for later periods of growth. Seeley[6] has pointed out that the temperature of the plant itself is widely different from that of the air which surrounds it, especially when the sun is shining, and suggests that plant temperatures be used instead of air temperatures in studies of plant growth. He found that plant leaves were, on the average, 15° F. warmer at midday, in clear weather, than the air temperature, 10° F. warmer when the sun was partially obscured in partly cloudy weather, and practically the same temperature on cloudy days. These averages were obtained from over 300 observations made during the growing season of 1915 and 1916. He proposes a formula for evaluating air temperatures in terms of the true plant temperature as follows: $T = t - 42\ N + 15\ C + 10\ P$, where "t," is the sum of the daily maximum temperatures during a given period, "N" the number of days in the period, "C" the number of clear days and "P" the number of partly cloudy days. Applying this formula to the average temperatures at a number of stations in Michigan, using the normal number of clear, partly cloudy and cloudy days during the growing season, in each section, gives a more accurate idea of the true thermal conditions under which crops grow in this state. Chart XIV shows the results obtained in this way. It will be noted that the largest value, 7183 is about 40 per cent greater than the least value, 5048, the stations having these values being, respectively, Adrian, in the extreme

southern, interior, portion of the state, and Calumet, in the extreme north and on Lake Superior. It will be noted that the interior of the state has much higher thermal values than sections near the lakes.

With further study and research accurate methods will probably be evolved for definnig the suitability of the temperature in any section to meet the plant requirements, but at present only the most general terms

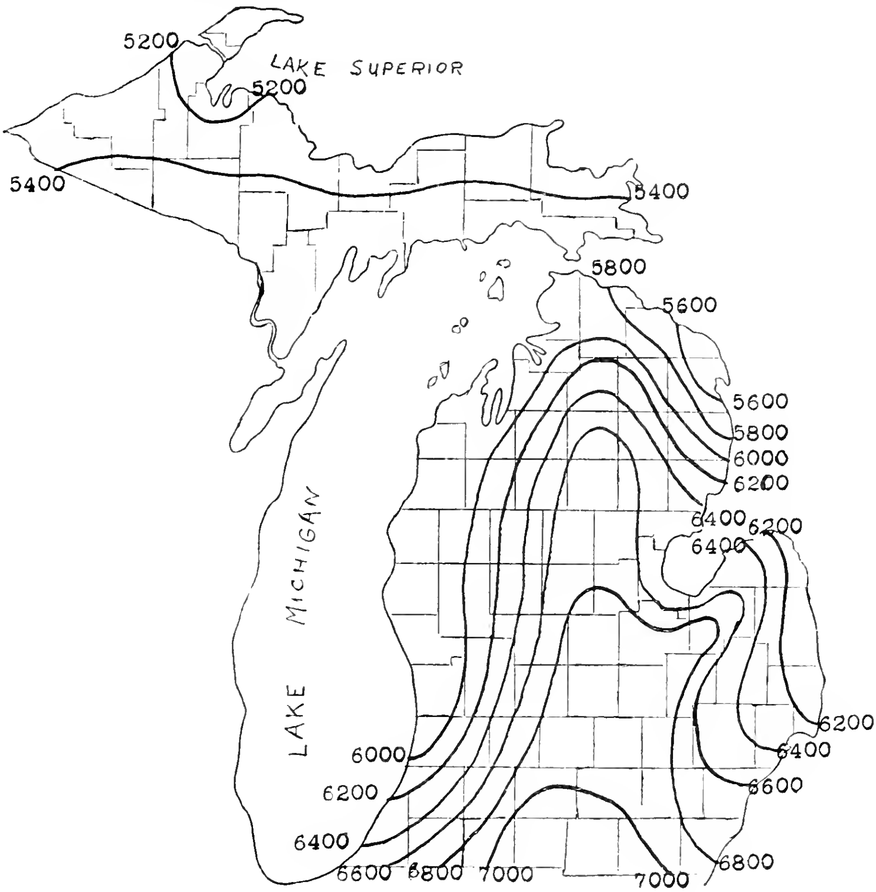

CHART XIV.-Thermal efficiency of Michigan, found by evaluating air temperatur in terms of plant temperature, by use of formula.

can be used. The cereal crops grown in Michigan more or less extensively are corn, wheat, oats, barley and rye. They each find temperature conditions to be a limiting factor, to a greater or less degree, in the production of a maximum crop in a rather large per cent of years.

Corn is grown to a considerable extent in Michigan, especially in the southern portion, but at least in the northern portion it is not grown as successfully as it is in the "Corn Belt" states. The plant requires a rather long frostless season, with warm nights for best results, and these

conditions are not found in the northern portion of the state. The crop will mature in 100 to 120 days when the weather is sufficiently warm, but 120 to 130 days are necessary to ripen it well if the weather is cool. Referring again to Charts XI, XII and XIII, showing frost dates and the length of the frostless season in various sections of Michigan it will be seen that many portions of the state are unsuitable for corn.

The winter varieties of wheat are grown exclusively in Michigan because there is usually sufficient snow to protect the crop through the winters, which are not so severe, as has been pointed out, as those in the northwest. Some "winter killing" occurs largely on account of alternate freezing and thawing when the ground is bare, but on the average the yield is satisfactory. The same statements apply to rye, which is also sown in the fall.

Oats and barley seem to find satisfactory temperature environment in nearly all portions of the state, and good crops are usually obtained where the soil is suitable.

Other crops which are successfully grown in Michigan on account, in a measure, of favorable temperature conditions, are hay, potatoes, beans, sugar beets, cucumbers, peas, chicory, mint and various other minor crops. It is doubtful if any other state in the union has a wider range of crops of rather large proportions than this state, largely due to the combination of marine and continental temperature conditions of this state and the local variations of other climatic elements as well, which have already been noted.

Fruit is a leading product of Michigan, largely on account of the very favorable climatic conditions produced by the Great Lakes. A narrow strip of the state extending along Lake Michigan is especially adapted to fruit and has been given the name of the "Fruit Belt" because of this fact. Among the climatic conditions found in this section that are favorable to fruit growing are, first, the continuation of cool weather into late spring which tends to retard the opening of fruit buds until danger from late frosts is past; second, unusually clear and not too hot summer weather, which produces good color and flavor in the fruit; third, prolonged cool falls, with freedom from early frosts, which tends to ripen up the wood properly, and, fourth, a moist atmosphere and freedom from extreme cold in winter which prevents winter injury. The fruit industry is still in its infancy in this favored section, but growers are beginning to realize the possibilities of the region.

The precipitation which normally falls in Michigan is sufficient for the crops which have been mentioned. But here again statements of exact relationships are as yet impossible. Briggs and Shantz[7] have worked out the actual rainfall requirements to produce a pound of dry weight in corn and Smith[8] has found that the yield of corn, potatoes and other crops is largely a matter of securing the required amount of moisture during certain short critical periods. Investigations in Italy and Russia have indicated that wheat also has a "critical period" during which the yield is determined by the amount of rain then available. But much more work must be done before the rainfall efficiency for crops can be stated for any section.

In general it is important that the precipitation for the year should be ample, and also that it should be suitably distributed through the months so that a sufficient supply will be available when the crops are

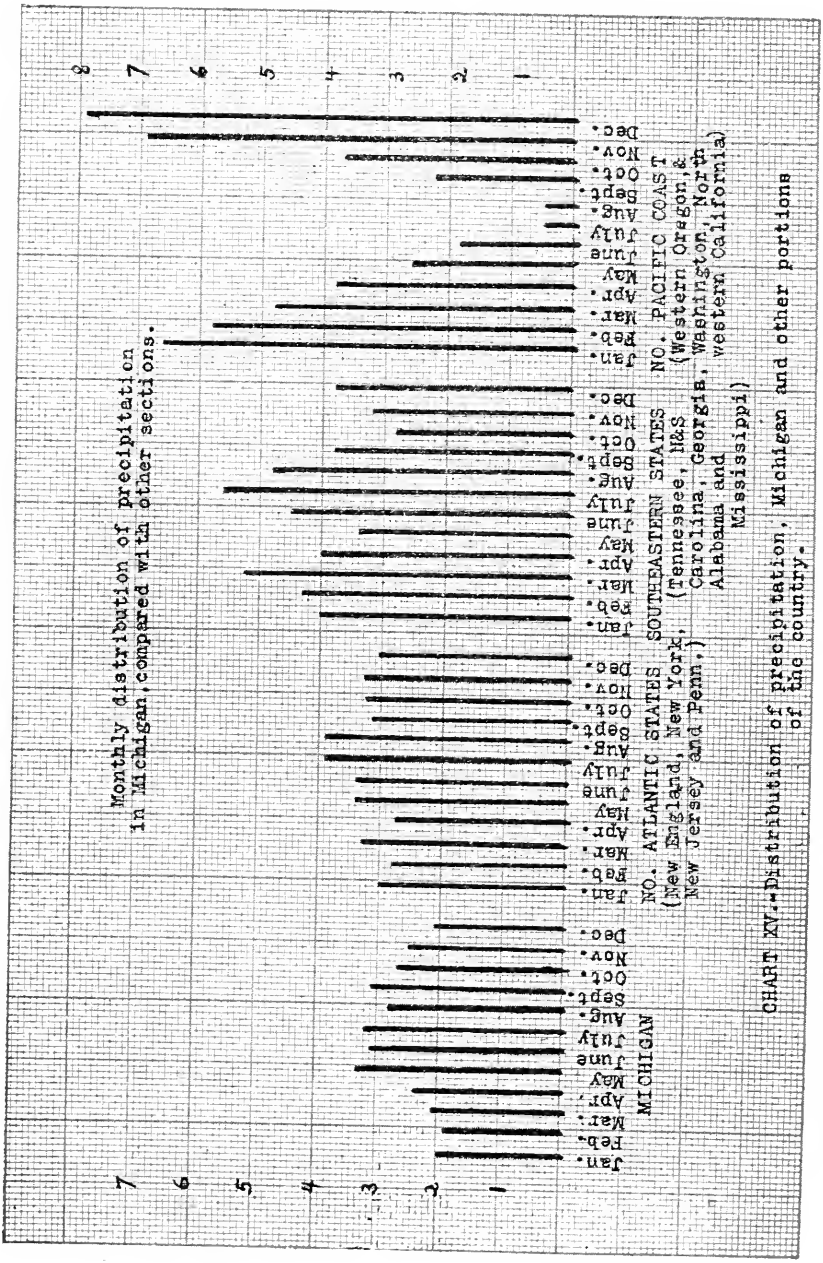

CHART XV.—Distribution of precipitation, Michigan and other portions of the country.

growing and maturing. Reference to Chart IX shows that the most rain falls from May to September, in all parts of the state, and these are the months that it is most needed. Chart XVI shows the distribution in Michigan compared with that in other portions of the country, by which it will be seen that an equally satisfactory distribution does not obtain in all other sections. Occasional droughts occur in portions of the state which seriously shortens yields. One of the most serious of such droughts was that of July and August, 1916, which markedly reduced the crops of corn, potatoes, beans, sugar beets and other crops in most portions of Michigan. This affords a good opportunity for studying the relationship between precipitation shortage and crop shortage, and Chart XVI has been constructed to bring out this relationship. It will be noted that the yields of corn and potatoes are directly proportional to the July rainfall. With the exception of potatoes in the northern portion of the lower peninsula the length of the lines representing the crop yields are in the same proportion as the lines representing rainfall in July, and this discrepancy may be accounted for by the fact that in the heavy potato producing counties in this northern section, along Lake Michigan, the rainfall was much heavier than that in the interior of the state and the eastern portion. The average yield was therefore enlarged in those sections thereby unduly increasing the general average. In Leelanau county, for example, the rainfall for July was about two inches and the average yield 130 bushels per acre, while in Kalkaska county nearby, the rainfall in July was little over half an inch, and the yield of potatoes but 20 bushels per acre.

The yield of beans seems to be less closely related to the July rainfall than the other two crops mentioned, but a closer study indicates that rainfall in August is a determining factor on the yield of this crop. The average July rainfall in 1916 in ten counties which had the largest yield of beans per acre in the state that fall, was 0.96 inches and the August rainfall in the same counties 3.26 inches, while in the ten counties which yielded the least the July rainfall was about the same as in the other ten, 0.88 inches, but the August rainfall was only 2.02 inches, or more than a third less than fell in the ten counties yielding the most. The more or less even distribution of rain over the growing season is therefore an important consideration where such a variety of crops is raised.

In at least two respects the unusual amount of cloudiness near the windward shores of the lakes during the winter season, mentioned in Part II, has an important bearing on agriculture. One of these is the beneficial and protective influence on fruit trees over winter, as stated. Were it not for this cloudy, moist atmosphere injury would more often result, as it does in other sections, from drying out of the wood. Second, cloudiness prevents thawing of wheat and rye fields on winter days, which is injurious when followed by freezing at night.

On the other hand the larger number of clear days over much of Michigan in the summer season, as compared with adjoining states, is a decided advantage to practically all crops, but especially to sugar beets and fruit, producing not only larger crops but of better quality.

The direct bearing of wind velocity and direction on crops is slight and difficult to trace, but indirectly these elements play an important part as they largely influence the other atmospheric conditions.

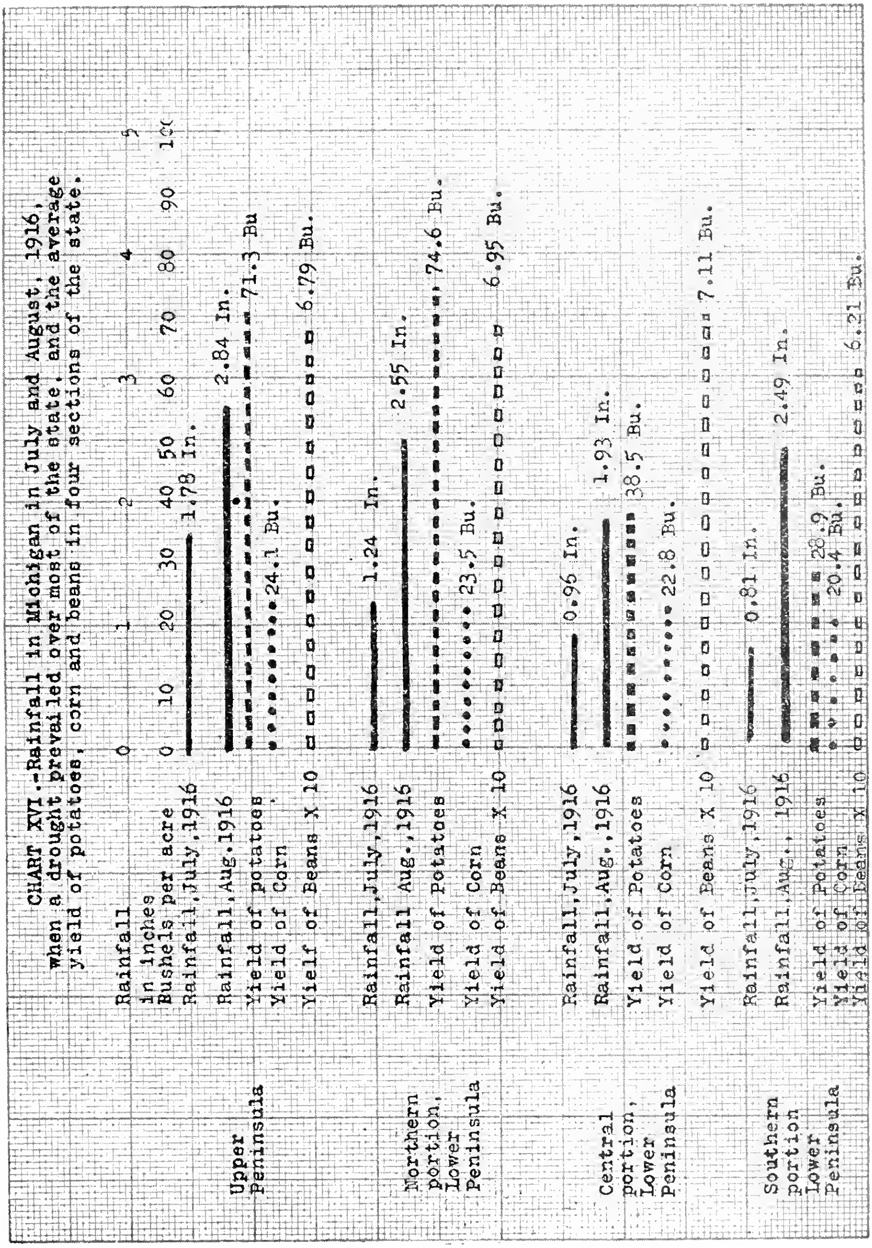
CHART XVI.-Rainfall in Michigan in July and August, 1916, when a drought prevailed over most of the state, and the average yield of potatoes, corn and beans in four sections of the state.
Rainfall in inches
0 1 2 3 4
Bushels per acre
0 10 20 30 40 50 60 70 80 90 100
Upper Peninsula
Rainfall, July, 1916 1.78 In.
Rainfall, Aug. 1916 2.84 In.
Yield of potatoes 71.3 Bu.
Yield of Corn 24.1 Bu.
Yielf of Beans X 10 6.79 Bu.
Northern portion, Lower Peninsula
Rainfall, July, 1916 1.24 In.
Rainfall Aug., 1916 2.55 In.
Yield of Potatoes 74.6 Bu.
Yield of Corn 23.5 Bu.
Yield of Beans X 10 6.95 Bu.
Central portion, Lower Peninsula
Rainfall, July, 1916 0.96 In.
Rainfall, Aug., 1916 1.93 In.
Yield of Potatoes 38.5 Bu.
Yield of Corn 22.8 Bu.
Yield of Beans X 10 7.11 Bu.
Southern portion Lower Peninsula
Rainfall, July, 1916 0.81 In.
Rainfall, Aug., 1916 2.49 In.
Yield of Potatoes 28.9 Bu.
Yield of Corn 20.4 Bu.
Yield of Beans X 10 6.21 Bu.

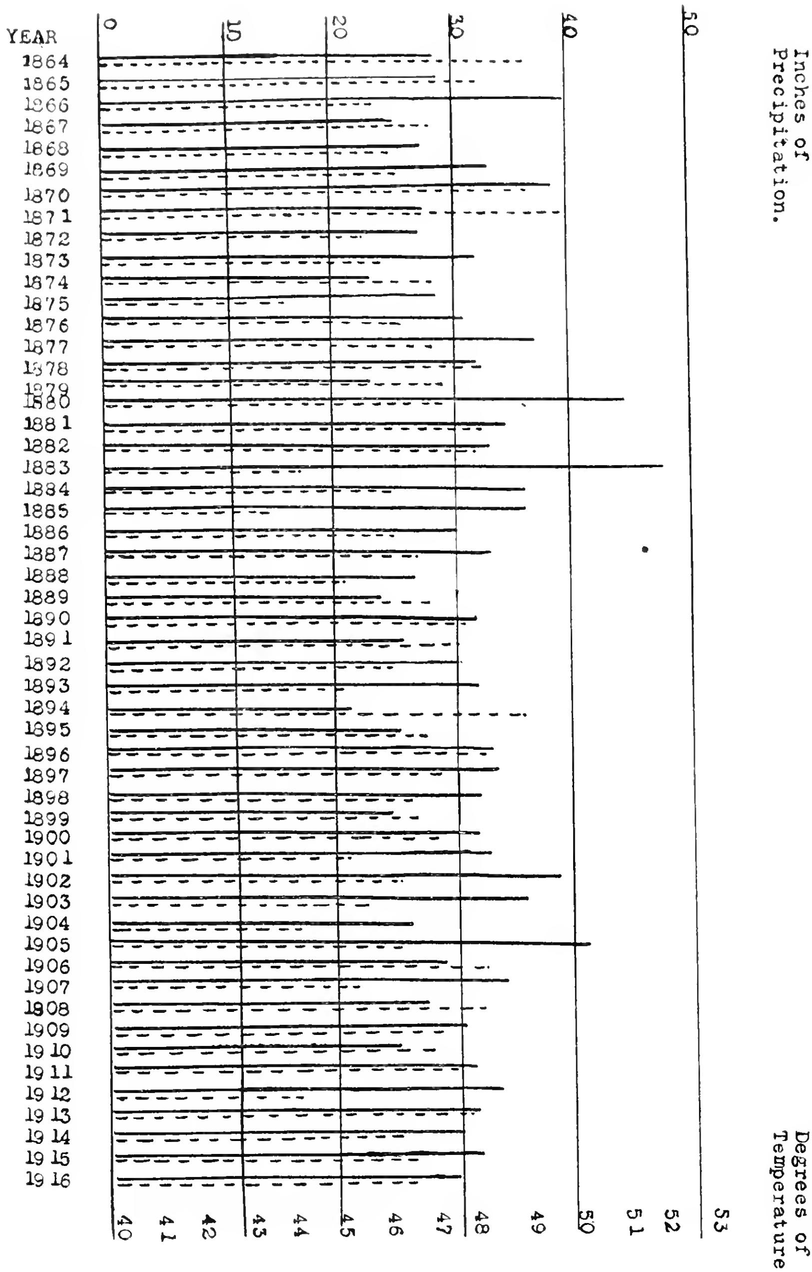

CHART XVII.—Total precipitation and mean temperature for the years 1864 to 1916, inclusive, at Lansing, Mich. (Precipitation in solid and temperature in dotted lines.)

The occurrence of peculiar phenomena, such as hail, tornadoes, torrential rains, etc., cause more or less destruction to crops. They are all local in character and hardly need be discussed here. The aggregate loss to farmers from these severe weather conditions is not large, but individual losses are sometimes heavy.

Just a word should be added to the effect that the climate is not changing, and therefore favorably or unfavorably affecting agriculture. Many persons seem to believe that the climate is different now than it was a half century ago, but a careful study of accurate records made for long periods shows no change in average conditions. Chart XVII was constructed from records begun in 1863 at the Michigan Agricultural College, by Dr. R. C. Kedzie, and carried on by him for nearly forty years, with almost no interruption, and continued since his death by other observers. This chart shows irregular fluctuations from year to year, but no permanent change, or tendency to change in any direction. The average of any ten consecutive years' records, during the period, either of rainfall or temperature, will be found to be about equal to that of any other period of the same length.

SUMMARY.

The purpose of this paper is to describe the climate of Michigan, and explain its peculiarities, and then to correlate the climate as described with the agriculture of the state.

The influences which control climate are four, namely latitude, altitude, environmental conditions, and the location relative to the normal storm paths.

The temperature decreases in this and other sections about one degree per one-hundred miles in distance away from the equator. A rise of 300 feet in elevation causes a drop in temperature of about 1° F. The presence of the Great Lakes causes marked differences in the climate of Michigan, as compared with other sections. The windward side of the lakes have a much more equable temperature, more snowfall and cloudiness in winter and more sunshine in summer, than interior regions. The fact that Michigan is in the direct path of cyclones and anti-cyclones results in frequent weather changes, more precipitation which is well distributed, and invigorating weather conditions generally.

On the whole the climate of Michigan is not extreme in temperature, either in summer or winter, the rainfall is sufficient for most crops, the greater portion of the year's supply falling during the growing season; the cloudiness is greater in winter and less in summer than in regions remote from the Great Lakes; the humidity is rather high throughout the year, especially on the lake shores; the prevailing winds are westerly, often high on the lakes but decrease as they pass inland. Severe local phenomena such as hail, tornadoes, torrential rains, etc., occur infrequently.

The usual cereal crops grown in the central valleys are raised in Michigan. Corn can be grown about as successfully in southern Michigan as in the "Corn Belt," but the seasons are often too short in the northern portion of the state to mature the crop. Wheat, oats, rye, barley, potatoes, beans, sugar beets, are all important crops, while many minor crops are also produced. There are localities where each seems

to find particularly favorable climatic conditions in the state, which has an unusually wide variation in climate. The "Fruit Belt" along the Lake Michigan coast is peculiarly adapted, as to climate for growing fruit on account of its cool springs, moderate summers with much sunshine, late falls and mild winters with much snow and cloudiness.

The climate is not changing as shown by a study of over fifty years of records made at the Michigan Agricultural College.

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The meteorological data used in this paper were extracted from publications of the U. S. Weather Bureau, largely Climatological Reports, Michigan Section, also Bulletin "Q," Climatology of the United States, U. S. Weather Bureau, 1906. Figures on crop yields were taken from the Michigan Crop Report, 1915-1916, published by the Secretary of State, Lansing, Mich.

Chart XVIII.—Map showing location of meteorological observing stations in Michigan.

MICHIGAN STATE AGRICULTURAL SOCIETY

ANNUAL REPORT

AND

AUDIT AND EXAMINATION

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1916

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REPORT OF SECRETARY-MANAGER

To the Members of the Executive Committee:

From the reports received from different sources, it is very evident that the people of Michigan have come to realize the importance of the Michigan State Fair as one of great educational value. The past year has demonstrated that the support on the part of the State Government was a wise one and it is hoped that the unqualified endorsement of the people will warrant more liberal consideration in the future. The appropriation made by the 1915 legislature of $50,000.00 each year for the years 1915 and 1916, has been apportioned and this year the Michigan State Fair received $16,000.00, the same as in 1915, for the payment of premiums offered to Michigan exhibitors and the same has been applied on premiums paid. In conversation with many of the Fair Secretaries I am sure that the members of the different Fair Boards throughout the State which have received State aid, endorse the action of the legislature in making such appropriation and feel very kindly toward securing a continuous appropriation at the next session.

The receipts of our 1916 Fair, as shown by the Auditor's Report, amount to $196,408.67. This is considerable in excess of the receipts in former years. Our expenditures for 1916 amount to $153,996.61, which leaves us a net gain of $42,412.06, which is, I am sure, very gratifying to us all.

The weather conditions during the full ten days of the Fair were ideal; only one afternoon and evening were we interferred with in any way by rain. We were also fortunate in having no accidents. The Auditor's Report together with the Report of the Superintendents of each Department will give in detail the history of the workings of our Fair.

$150,000 Bonds:

In accordance with the recommendation of your Secretary-Manager, which was approved at a special meeting of the Executive Committee held April 14th, 1916, that we make an additional bond issue of $150,000.00 for the purpose of making permanent improvements on the Grounds, I wish to report that a second mortgage bond issue made in 1915 of $60,000.00 and sold to the Dime Savings Bank was taken up and there was issued $210,000.00 of second mortgage bonds dated May 1st, 1916, and falling due May 1st, 1920, $60,000.00 of which was turned back to the Dime Savings Bank at a discount of 1%, which left us $150,000.00 of second mortgage bonds for sale, in accordance with your order.

$25,000.00 of the $150,000.00 bond issue was sold to the American Savings Bank of Pontiac at par and the remaining $125,000.00 of bonds are still in our possession. During the year we have paid $10,000.00 of the bonds falling due and interest amounting to $15,150.00. There are now outstanding $260,000.00 of bonds sold and $125,000.00 second mortgage bonds unsold, which is plainly set forth in the Auditor's Report.

Permanent Improvements:

The Auditor's Report will show the permanent improvements made, which cover the construction of a Woman's Building, Art Building, New Entrance, Post Lighting System, Sidewalks, Stone Roads, enclosing the Machinery Hall and a Lodge for the Grounds Superintendent, the foundation of which was started in 1913, a total expenditure of $43,328.66. The balance of the cost of the permanent improvements made over the $15,000.00 of bonds issued was taken from our 1916 receipts.

Soon after starting the construction of the buildings, it was discovered that owing to the high cost of material and scarcity of labor, it would be very difficult to go on with all of our improvements.

Fire at Grounds:

In regard to the destruction of the five speed barns and damage to Swine Barn K. by fire, which occurred at the Fair Grounds on Sunday, March 18th, 1916, I wish to report that we built three speed barns 30 x 240 feet each, with a capacity covering four of the

old barns at a cost of approximately $10,000.00 being the exact amount received from the insurance company. The $375.00 received from the insurance company on damage to Swine Barn K. fully took care of the repairs to same. In addition to the permanent improvements we have expended during the year $5,411.63, in repairs to our buildings and equipment which were much needed and leaves them in fairly good condition, leaving us more than a sufficient amount of money on hand to pay the $10,000.00 of bonds falling due May 1st, 1917, and interest on our total bond issue.

Insurance:

The buildings have been reinsured this year at a cost of $2,307.38. We also carry Employes' Liability insurance with the Casualty Insurance Company of America at a cost of $236.94, an increase over last year of $154.54, which was caused on account of the extra men employed in the construction work.

Auto Races:

We had three days of Auto Races, May 28th and 30th and June 4th, the gross receipts of which amounted to $8,339.50. On July 4th we had Ford auto races, the gross receipts of which were $2,156.90. During the year on June 11th, July 9th and August 13th we leased the track to the Interstate Racing Association of Toledo, Ohio, for $400.00 per meet.

It has been the custom of the Greenfield officers to charge us $25.00 per day for a township fee for races on our tracks, which has been paid by our Society in former years. When they confronted us with a bill this year, I paid the first one under protest and took the matter up with the Attorney General, who gave it as his opinion that we were not subject to any township taxes for the operation of our races and I so notified the township officers, since which time this tax has not been imposed upon us.

Rental of Buildings:

We received from the rental of Buildings during the year $15,896.50. We now have contracts with the Studebaker Corporation, Maxwell Motor Car Company, Hupmobile Company and the Dodge Bros. Auto Company, covering six months from October 15th, 1916, to April 15th, 1917, for a trifle over $11,000.00. We are storing a few cars for the Reo-Mitchell and have space for from 400 to 500 cars, which no doubt will be occupied at least a part of the season, in addition to the leases which are in effect being extended after April 15th, as they were last spring.

Old Mill:

During the year we made a contract with the Welcher Construction Company, covering a period of ten years for the construction of an Old Mill at a cost to that company of about $16,000.00, we to receive 20% of the gross receipts, which this year netted us $807.38.

STATE EXHIBITS

The following named State Departments made exhibits at our 1916 Fair, which were very creditable and interesting to the public in general.

Michigan Fish Commission:

The Fish Exhibit under the supervision of State Superintendent Bower, was held under the west side of the Grand Stand and was far superior to that held in the same place last year.

Michigan State Prison:

The Jackson prison exhibit was placed in the Machinery Hall and was certainly interesting in an educational way to our visitors. Much credit is due Warden Simpson for the judicial, painstaking and conscientious work done along this line in behalf of our penal institution. It goes to show that when the proper method is applied in the handling of any of the State institutions, there is a great opportunity for improvement over the old system, and I am sure it was a means of imparting valuable information to the people of our State concerning prison life. This exhibit is worthy of special mention.

State Board of Health:

The State Board of Health, under the direction of Dr. John L. Burkhart, made a splendid exhibit and imparted valuable information to our visitors.

State Highway Commission:

The State Highway Commission in connection with the Engineering Department of the University of Michigan, made a very interesting exhibit, not only showing the development in the building up of our roads throughout the State, but an exhibit showing the ingredients used in their construction.

State Dairy and Food Department:

The State Dairy and Food Department took charge of our Dairy exhibit and held their quarterly inspection of butter and cheese. Although the exhibit was light, it was worthy of special mention.

If the State could be induced to construct a building of sufficient size to take care of all of the State exhibits, I am sure a much better showing would be made, as we were handicapped this year by not having room enough to properly house the State Departments, which favored us with an exhibit. A great many of the State Departments would be inclined to make exhibits at the Fair if a suitable building was built for their convenience and I feel certain that the legislature would give consideration to the appropriation of sufficient money to cover the cost of a Michigan exhibit building, if the matter was properly presented.

DEPARTMENTAL EXHIBITS

Horses:

The Horse Department, although handicapped to some extent on account of the threatened railroad strike, was given credit for having a much better and larger exhibit than ever before. There were more horses entered in this Department than we were able to care for in our exhibit barns and the overflow was housed in the old Poultry building and such exhibitors were not charged for stall rent.

Cattle, Sheep and Swine:

The Cattle, Sheep and Swine Departments suffered somewhat in the same manner as the Horse Department, on account of the threatened strike. The barns were full and the exhibit was good, with the exception of the Dairy class. For some reason the breeders of Michigan do not give as much attention to the exhibit of Dairy breeds at our Fair. Interest might be stimulated in this particular department if the National Dairy Show was located in Detroit. We had a fine exhibit of sheep and also of swine and the exhibitors seemed well pleased with the treatment they received.

Poultry:

The poultry exhibit was lighter than last year, caused by changing the premium list somewhat and cutting out the hucksters, but we really had more exhibitors, although a less number of birds than in 1915, nevertheless, this exhibit was very interesting.

Farm Products:

The Farm Products in the Agricultural Building was a much better show than in 1915. Taking into consideration the dryness of the season we had an exceptionally good exhibit.

Fruits, Plants and Flowers:

The Fruits certainly made a fine display and although the weather conditions during the season were not ideal for the growing of Fruits, caused by the continued drought, we had a very good show. The Plant and Flower exhibit was very light and the dry season prevented many of our old exhibitors from showing.

Machinery, Implements and Vehicles:

This exhibit was very interesting this year. Several tractor exhibits helped to make up the show and as a whole it was very creditable. The exhibit in the Building was considerably better than ever before.

Dairy, Domestic and Apiary:

In the Dairy Department the rearrangement of the Building, the construction of the fountain in the center and the moving of the ice box to the north end of the building gave a very attractive appearance and the exhibitors seemed to be well pleased with the changes made. The space was all sold several weeks before the Fair opened, although the rate was increased over 1915 from 15 cents to 25 cents per square foot.

In the Domestic Department, we had a very good exhibit in the way of food stuff and canned fruit and from what can be learned from the exhibitors and visitors at the Fair we will have a much larger exhibit next year.

In the Apiary Department we had but one exhibitor this year, although we increased the premiums more than 100%. This was due largely to the drought during the summer and also to the death of Mr. Nichols, who has been the largest and best exhibitor in the Apiary Department for many years past.

Needlework:

The Needlework exhibit was exceptionally good, although we were late in getting the upper floor of the Woman's Building ready for its occupancy. However, another year will see the finest needlework exhibit ever show in Michigan.

Handicraft and Fine Arts:

This was shown in our new Art Building and although this building was completed after the opening of the Fair, it was a point of much interest and found many admirers. I am sure these two buildings have had more to do with the increased interest of the women of Michigan in the Michigan State Fair and brought us in closer touch with the home than any other work we have attempted.

Educational Department:

The Educational Department was placed on the upper floor of the Administration Building and although somewhat short of room was very creditably arranged and had many visitors.

Boys' State Fair School:

The Boys' State Fair School was of unusual interest and I am sure is good advertising for the Michigan State Fair throughout the State, as it gets us in close touch with at least one home in every County in Michigan.

Physical Educational Department:

We held a Body-Building Contest covering a period of six months from March 1st to September 1st, 1916, in which we had 47 contestants.

We also held a Physique Beautiful Contest in which there were 4 contestants. We believe these are the first contests of this kind ever inaugurated at Fairs and think it will tend to create a spirit of physical evolution and more sanitary conditions, which cannot fail to be of great benefit to the people of our State.

We also had contests for boys and girls, which met with considerable favor, and in all, the Physical Educational Department is, I believe, a step in the right direction to encourage at Fairs.

Better Babies' Contest and Childs Welfare:

This was held on the first floor of the new Woman's Building and was a point of more than usual interest to all visitors of the Fair. This building with its accommodations was especially appreciated by the Women and Children of the State and next year will see greater interest in this Department because the building will be entirely finished.

SUMMARY OF AMOUNTS OF PREMIUMS OFFERED AND PAID

Departments	Premiums, Cups, Ribbons and Purses Offered	Premiums Paid In Mich.	Premiums Paid Out Mich.	Total Premiums Paid
Horses:				
Breeding	$4,746 00	$2,165 00	$1,038 00	$3,203 00
Horse Show	4,790 00	2,840 00	1,720 00	4,560 00
Speed Department	13,800 00	....	....	8,450 00
Cattle	8,292 50	4,423 50	1,693 50	6,117 00
Sheep	3,600 00	878 00	2,216 00	3,094 00
Swine	3,218 00	1,197 25	1,162 00	2,359 25
Poultry, Pigeons, Pet Stock	2,492 00	1,077 50	....	1,077 50
Farm Products	2,222 75	2,110 00	....	2,110 00
Machinery	25 00	....	....	....
Fruits	2,259 25	1,925 00	....	1,925 00
Plants and Flowers	1,217 00	545 00	....	545 00
Dairy, Domestic, Apiary	1,733 50	753 00	....	753 00
Needlework	730 00	335 25	....	335 25
Handicraft and Fine Arts	474 50	427 00	....	427 00
Educational	1,173 50	673 25	....	673 25
Boys' State Fair School	1,292 95	1,292 95	....	1,292 95
Better Babies	107 00	91 17	....	91 17
Total Cost Premiums	$38,373 95	$20,733 87	$7,829 50	$37,013 37
25%	....	....	....	2,111 61
Ribbons	460 25	....	....	460 25
Cups	897 00	....	....	783 00
Grand Total	$53,531 20	....	....	$40,368 23

HORSE DEPARTMENT

Amount of Premiums Offered and Paid

Breeding Classes

Classes	No. Entries In Mich.	No. Entries Out Mich.	Total Premiums Offered	Premiums Paid In Mich.	Premiums Paid Out Mich.	Total Premiums Paid
Standard Bred	29	2	$460 00	$289 00	$4 00	$293 00
Hackney	19	9	436 00	107 00	52 00	159 00
Percheron	31	31	620 00	345 00	173 00	518 00
Clydesdale	33	12	620 00	409 00	157 00	566 00
English Shire	2	2	620 00	40 00	25 00	65 00
Belgian	34	28	620 00	400 00	183 00	583 00
Welsh Ponies	3	17	265 00	....	105 00	105 00
Shetland Ponies	22	55	515 00	113 00	300 00	413 00
Heavy Draft Mares and Geldings	72	18	350 00	337 00	39 00	376 00
Jacks and Mules	11	....	240 00	125 00	....	125 00
Total	256	174	$4,746 00	$2,165 00	$1,038 00	$3,203 00

HORSE DEPARTMENT

Amount of Premiums Offered and Paid

Horse Show

Classes	No. Entries In Mich.	No. Entries Out Mich.	Total Premiums Offered	Premiums Paid In Mich.	Premiums Paid Out Mich.	Total Premiums Paid
Roadsters	21	3	$350 00	$250 00	$50 00	$300 00
Runabout Class	33	4	190 00	110 00	80 00	190 00
Harness Horses	39	14	800 00	535 00	210 00	745 00
Gig Horses	8	4	100 00	70 00	30 00	100 00
Ladies' Class	6	6	270 00	25 00	205 00	250 00
Four-in-Hand and Tandems	2	5	260 00	20 00	205 00	225 00
Championship Harness	2	1	50 00	50 00	....	50 00
Saddle Horses	105	47	1,075 00	580 00	510 00	1,090 00
Shetland Ponies	30	33	220 00	65 00	150 00	215 00
Welsh Ponies	2	8	105 00	10 00	85 00	95 00

	No. Entries In Mich.	No. Entries Out Mich.	Total Premiums Offered	Premiums Paid In Mich.	Premiums Paid Out Mich.	Total Premiums Paid
Ponies other than Shetland to Harness	6	18	$220 00	$35 00	$195 00	$230 00
Police Mount	1	....	200 00	200 00	....	200 00
Heavy Delivery	....	....	200 00	....	....	....
Hunters and Jumpers	111	....	750 00	870 00	....	870 00
Horse Show Total	366	143	$4,790 00	$2,840 00	$1,720 00	$4,560 00
Breeding Classes	256	174	4,746 00	2,165 00	1,038 00	3,203 00
25% to Michigan Exhibitors	....	....	....	....	....	521 25
Ribbons	....	....	....	....	....	167 04
Cups	....	....	176 00	....	....	154 00
Speed Department	294	....	13,800 00	....	....	8,450 00
Grand Total	916	317	$23,512 00	$5,005 00	$2,758 00	$17,055 29

Speed Department

No. of Entries	No. of Starters	Class	Amt. of Purse Offered	Amt. Paid	Amt. Entry Fee Collected	Net Cost
		Trotting				
25	5	2:28	$1,000 00	$720 00	$270 00	$530 00
22	10	2:19	1,000 00	720 00	270 00	530 00
7	Declared off	2:14	1,000 00	....	....	....
8	Declared off	2:18 3 years old	600 00	....	....	....
15	9	2:30	600 00	480 00	270 00	210 00
17	10	2:19	600 00	480 00	210 00	270 00
15	5	2:12	600 00	480 00	150 00	330 00
19	8	2:16	600 00	480 00	210 00	270 00
21	14	2:22	600 00	480 00	420 00	60 00
..	Declared off	2:10	600 00	....	....	....
		Pacing				
21	8	2:24	1,000 00	720 00	300 00	500 00
19	7	2:18	1,000 00	720 00	270 00	530 00
13	4	2:13	1,000 00	720 00	150 00	650 00
18	6	2:28	600 00	480 00	180 00	300 00
14	4	2:14	600 00	480 00	120 00	360 00
..	Declared off	2:10	600 00	....	....	....
20	12	2:16	600 00	480 00	360 00	120 00
17	7	2:20	600 00	480 00	180 00	300 00
23	7	2:22	600 00	480 00	240 00	240 00
294		Totals	$13,800 00	$8,400 00	$3,600 00	$5,200 00
		1915 Purse to C. M. Williams paid in 1916		50 00		

CATTLE DEPARTMENT

Amount of Premiums Offered and Paid

Classes	No. Entries In Mich.	No. Entries Out Mich.	Total Premiums Offered	Premiums Paid In Mich.	Premiums Paid Out Mich.	Total Premiums Paid
Shorthorns	118	38	$1,208 50	$673 50	$308 50	$982 00
Polled Durham	70	25	671 00	278 00	223 00	501 00
Hereford	52	23	671 00	266 00	233 00	499 00
Aberdeen Angus	77	....	671 00	446 00	....	446 00
Galloway	....	36	663 00	....	233 00	233 00
Red Polled	34	35	671 00	295 00	231 00	526 00
Jersey	43	....	655 00	379 00	....	379 00
Guernsey	67	....	657 00	518 00	....	518 00
Holstein-Friesian	33	....	671 00	315 00	....	315 00
Ayrshire	45	32	657 00	336 00	219 00	555 00
Brown Swiss	52	29	607 00	283 00	236 00	519 00
Dutch Belted	19	....	....	234 00	....	234 00
Dairy Cows	4	1	100 00	100 00	10 00	110 00
Fat Steers	14	....	260 00	170 00	....	170 00
Herdsman's Special	5	1	30 00	30 00	....	30 00
Michigan State Fair Special	1	....	100 00	100 00	....	100 00
Total	634	220	$8,292 50	$1,423 50	$1,693 50	$6,117 00
25% to Michigan Exhibitors	....	....	....	....	....	1,073 36
Ribbons	....	....	....	....	....	55 59
Cups	....	....	231 00	....	....	198 00
Grand Total	634	220	$8,523 50	$4,423 50	$1,693 50	$7,443 95
Refund made by American Short Horn Breeders Association						407 08

SHEEP DEPARTMENT

Amount of Premiums Offered and Paid

Classes	No. Entries In Mich.	No. Entries Out Mich.	Total Premiums Offered	Premiums Paid In Mich.	Premiums Paid Out Mich.	Total Premiums Paid
Shropshire	21	21	$270 00	$93 00	$138 00	$231 00
Hampshire	54	41	270 00	77 00	191 00	268 00
Oxford Downs	48	27	270 00	107 00	131 00	238 00
South Downs	56	34	270 00	8 00	217 00	225 00
Horned Dorsets	25	72	270 00	263 00	170 00	233 00
Tunis	....	32	270 00	....	114 00	114 00
Cheviots	29	61	270 00	131 00	217 00	248 00
Cotswold	29	49	270 00	23 00	226 00	249 00
Leicester	30	32	270 00	30 00	197 00	227 00
Lincoln	18	66	270 00	7 00	221 00	228 00
Delaine Merino	51	54	270 00	118 00	143 00	261 00
American Merino	42	60	270 00	93 00	162 00	255 00
Rambouillet	48	32	270 00	162 00	89 00	251 00
Fat Sheep	36	3	90 00	66 00	....	66 00
Total	487	584	$3,600 00	$878 00	$2,216 00	$3,094 00
25% to Michigan Exhibitors	....	....	....	....	....	219 50
Ribbons	....	....	....	....	....	39 17
Cups	....	....	243 00	....	....	225 00
Grand Total	487	584	$279 00	$878 00	$2,216 00	$3,577 67

SWINE DEPARTMENT

Amount of Premiums Offered and Paid

Classes	No. Entries In Mich.	No. Entries Out Mich.	Total Premiums Offered	Premiums Paid In Mich.	Premiums Paid Out Mich.	Total Premiums Paid
Berkshire	67	20	$352 00	$126 00	$126 00	$252 00
Poland China	65	32	352 00	125 00	153 00	278 00
Hampshire	55	34	352 00	125 00	153 00	278 00
Victoria and Small Yorkshire	29	....	352 00	203 00	....	203 00
Chester White	101	33	352 00	152 00	141 00	293 00
Large Yorkshire	21	19	352 00	30 00	....	30 00
Mulefoot	50	56	352 00	74 00	278 00	352 00
Duroc Jersey	98	84	352 00	231 00	121 00	352 00
Tamworth	28	32	352 00	101 25	190 00	291 25
Fat Hogs	8	....	50 00	30 00	....	30 00
Total	522	310	$3,218 00	$1,197 25	$1,162 00	$2,359 25
25% to Michigan Exhibitors	....	....	....	....	....	297 50
Ribbons	....	....	....	....	....	33 70
Cups	....	....	162 00	....	....	144 00
Grand Total	522	310	$3,380 00	$1,197 25	$1,165 00	$2,834 45

POULTRY DEPARTMENT

Amount of Premiums Offered and Paid

Classes	No. Entries	Total Premiums Offered	Total Premiums Paid
Poultry	568	$1,176 00	$525 50
Bantams	149	372 00	145 00
Ornamental Fowls	6	24 00	5 50
Turkeys, Geese, Ducks	96	346 00	132 50
Pigeons	255	244 00	160 00
Hares, Cavies	119	330 00	109 00
Total	1193	$2,492 00	$1,077 50
Ribbons	....	....	155 55
Grand Total	1193	$2,492 00	$1,233 05

FARM PRODUCTS

Amount of Premiums Offered and Paid

	No. Entries	Total Premiums Offered	Total Premiums Paid
Grains and Seeds	150	$348 00	$338 00
Forage Plants	49	153 00	150 00
Corn	162	308 00	283 50
Roots and Vegetables	663	1,413 75	978 50
Special	....	....	360 00
Total	1024	$2,222 75	$2,110 00
Cups	....	33 00	11 00
Ribbons	....	....	2 00
Grand Total	1024	$2,255 75	$2,123 00

PLANTS AND FLOWERS

Amount of Premiums Offered and Paid

Classes	No. Entries	Total Premiums Offered	Total Premiums Paid
Plants in Pots	9	$331 00	$193 00
Plants in Boxes and Baskets	2	53 00	25 00
Cut Flowers (Professional)	13	521 00	283 00
Plants (Amateur)	6	97 00	20 00
Cut Flowers (Amateur)	5	72 00	24 00
Private Gardeners only	....	143 00	....
Total	35	$1,217 00	$545 00

FRUITS

Amount of Premiums Offered and Paid

Classes	No. Entries	Total Premiums Offered	Total Premiums Paid
Special County Exhibit	10	$1,049 00	$879 00
Single Plates	1573	583 25	493 00
Exhibition Boxes	408	627 00	553 00
Total	1981	$2,259 25	$1,925 00

1915 Premiums paid in 1916:

James Billings	$102 65	
Geo. Hawley	47 40	
		$150 05

DAIRY, DOMESTIC AND APIARY

Amount of Premiums Offered and Paid

Classes	No. Entries	Total Premiums Offered	Total Premiums Paid
Butter	37	$416 00	$121 94
Cheese	7	240 00	71 31
Milk	8	40 00	40 00
Milking Contest	4	32 50	32 50
Bread, Cakes and Pies	169	133 75	109 75
Puddings	14	42 00	27 00
Salads	39	42 00	41 50
Canned Fruits and Vegetables	61	42 00	43 00
Preserves, Jams, Jellies and Pickles	260	132 75	114 00
Wines	15	17 50	12 00
Apiary	8	595 00	140 00
Total	622	$1,733 50	$753 00
Cups	....	9 00	....
Grand Total	622	$1,742 50	$753 00
1915 Premium paid in 1916—Emma R. Dales			4 19

NEEDLEWORK DEPARTMENT

Amount of Premiums Offered and Paid

Classes	No. Entries	Total Premiums Offered	Total Premiums Paid
Ladies' Underwear and Dress Accessories	65	$116 25	$39 00
Baby Wear—Embroidered	90	86 00	7 00
Household Articles and Home Decoration	194	196 25	83 75
Hand Crocheted or Knitted Articles	100	145 25	68 00
Baby Wear—Crocheted	40	67 25	2 00
Lace Making	80	23 25	26 50
Drawn Work and Fayal Weaving	22	31 00	19 50
Quilts	20	30 75	27 00
Antiques	85	9 00	45 00
Rugs and Portieres	26	25 50	17 50
Total	722	$730 50	$335 25

HANDICRAFT AND FINE ARTS

Amount of Premiums Offered and Paid

Classes	No. Entries	Total Premiums Offered	Total Premiums Paid
China Decoration	149	$162 50	$150 00
Basketry	7	11 00	8 00
Wood Carving	5	23 50	8 00
Metal Work	26	22 00	32 00
Clay Modeling	....	26 00	....
Original Design in Outline or Color	13	26 50	16 00
Interior Decoration	5	23 50	13 00
Photographs	8	30 00	29 00
Novelties	27	6 00	7 00
Paintings—Oil and Water Colors	124	109 00	129 50
Student's Work—Oil and Water Colors	24	34 50	14 00
Pastel	20	....	20 50
Total	408	$474 50	$427 00

EDUCATIONAL, INCLUDING BOYS' STATE FAIR SCHOOL

Amount of Premiums Offered and Paid

Classes	No. Entries	Total Premiums Offered	Total Premiums Paid
County Normal	....	$121 50	....
High School Work	59	121 00	$55 00
Grammar Grade	167	158 00	105 25
Intermediate Grades	104	152 00	105 75
Primary Grades	119	64 50	53 25
Kindergarten	21	15 75	9 75
Manual Training	115	191 75	108 00
Agricultural	32	49 50	22 50
Village Schools	63	125 50	71 75
District Schools	150	174 00	142 00
Total	830	$1,173 50	$673 25
Expense Boys State Fair School	....	....	1,292 95
Cups	....	27 00	....
Grand Total	830	$1,200 50	$1,966 20

BETTER BABIES CONTEST

Amount of Premiums Offered and Paid

Classes	No. Entries	Sterling Silver	Total Offered	Total No. Awarded
Babies from Rural Districts and Towns of 1000 population or less	9	Cup	4	2
		Napkin Ring	4	1
		Spoon	4	1
Babies from Cities and Towns of 1000 and less than 10,000 Population	6	Cup	4	4
		Napkin Ring	4	2
		Spoon	4	
Babies from Cities of over 10,000 population	50	Cup	4	4
		Napkin Ring	4	8
		Spoon	4	9

Sterling Silver Cups	1 doz. at	$68 00	$56 67
Sterling Silver Rings	1 doz. at	21 00	22 00
Sterling Silver Spoons	1 doz. at	15 00	12 50
Total		$107 00	$91 17
Ribbons		....	7 20
Grand Total			$98 37

AUDIT AND EXAMINATION

December 1, 1916.

Michigan State Agricultural Society, Detroit, Michigan,

Dear Sirs:—We have completed an audit and examination of your books and records for the period from December 1, 1915, to November 30, 1916, and submit herewith our report, together with the following exhibits and their supporting schedules.

Exhibit A—Balance Sheet.
Exhibit B—Statement of Revenues and Expenses.
Exhibit C—Comparative Statement of Revenues and Expenses—Condensed.
Schedule 1—Accounts Receivable.
Schedule 2—Suspensions—Speed Department.
Schedule 3—Comparative Statement of Plant Accounts.
Schedule 4—Sundry Accounts Payable.
Schedule 5—Deposits on 1917 Contracts.
Schedule 6—Miscellaneous Revenues.
Schedule 7—Administrative Expense.
Schedule 7A—Special Expense.
Schedule 8—Operating Expense.
Schedule 8A—Miscellaneous Operating Expense.
Schedule 9—Departmental Expense.

All reported cash receipts, as taken from the duplicate slips of the receipt book, were properly recorded and accounted for.

The bank account was reconciled every month. All disbursements were made by check, duly supported by properly approved vouchers.

Several of the old accounts receivable were charged off as bad debts. We believe, that some of the accounts still listed in Schedule 1 are of doubtful character, and we recommend that a sufficient reserve be set up which will approximate the probable losses.

The values of fixed assets are shown in the balance sheet as exhibited by the books. These assets, other than those acquired during the period covered, are subject to revaluation by appraisal.

The liabilities as set forth in the balance sheet represent all the ascertainable obligations of the Society at this time.

In addition to our usual duties pertaining to accounting, our work also covers an audit of the gate receipts and the verification of space allotted to the concessioners during the fair.

We are pleased to state that uniformly courteous treatment and painstaking effort was afforded our representatives during the entire progress of our work.

Respectfully submitted,
A. W. EHRMAN & CO.,
Public Accountants.

EXHIBIT A

BALANCE SHEET

As at November 30, 1916

ASSETS

Current:		
Cash on Hand	$795 94	
Peoples State Bank	14,966 76	
American Savings Bank	10,000 00	
Accounts Receivable (Schedule 1)	3,249 38	
Suspensions (Schedule 2)	7,910 50	
Investments	50 00	
		$36,972 58
Fixed:		
Land (Schedule 3)	$287,510 78	
Buildings (Schedule 3)	352,169 70	
Equipment (Schedule 3)	33,948 08	
		673,628 56
Inventory:		
Lumber, etc		728 97
Prepaid Charges:		
Bond Expense Prepaid		1,273 88
		$712,603 99

LIABILITIES

Current:			
Accounts Payable (Schedule 4)		$3,028 92	
Sundry Accrued Items		281 00	
Accrued Interest on Bonds		1,300 00	
			$4,609 92
Deferred Credits:			
Deposits on 1917 Contracts (Schedule 6)		$550 00	
Reserve for Lease Race Track		7,290 16	
			7,840 16
Mortgage Bonds:			
First Mortgage Bonds Authorized and sold		$200,000 00	
Less: Bonds Redeemed		25,000 00	
First Mortgage Bonds Outstanding		$175,000 00	
Second Mortgage Bonds Authorized	$210,000 00		
Less: Bonds Unsold	125,000 00		
Second Mortgage Bonds Sold		85,000 00	
Total Bonds Outstanding			260,000 00
Surplus—November 30, 1915	$398,685 83		
Less: Adjustments	853 60		
		$397,832 23	
Add: Net Profit December 1, 1915, to November 30, 1916 (Exhibit B)		42,321 68	
			440,153 91
			$712,603 99

EXHIBIT B

STATEMENT OF REVENUES AND EXPENSES

December 1, 1915, to November 30, 1916

REVENUES

Admissions:		
General Day Admission	$68,249 05	
General Night Admission	2,696 66	
Exhibitors' Tickets	1,398 00	
Membership Tickets	176 00	
Automobile	3,180 50	
		$75,700 21

Auto Races:		
Day Admission to Grand Stand	$6,160 50	
Night Admissions to Grand Stand	1,600 00	
Entrance Fees—Ford Races, July 4	190 00	
Entrance Fees—Ford Races, Sept 10	170 00	
Decoration Day Race	2,144 00	
June 4, Race	1,309 70	
July 4, Race	2,015 91	
		$13,890 11
Concessions:		
Agricultural Building	$175 00	
Dairy Building	50 00	
Grand Stand	850 00	
Main Building	225 00	
Midway Revenues	6,536 32	
Miscellaneous	19,300 00	
		27,136 32
Exhibits:		
Auto Building Rental	$5,000 00	
Auto Building Other Exhibits	25 00	
Dairy Building	1,366 00	
Grand Stand—Land Show	416 00	
Machinery Building	1,100 00	
Machinery Field	519 00	
Main Building	2,966 00	
Miscellaneous	896 00	
		12,288 00
Horse Show:		
Grand Stand Admissions	$3,593 80	
Box Seats	522 07	
		4,115 87
Speed Department:		
Booking Privilege	$3,750 00	
Entrance Fees	4,488 00	
Grand Stand Admissions	6,723 90	
Score Card Privilege	300 00	
Box Seats	1,320 18	
		16,582 08
Sundry:		
Electric Current Sales	$591 10	
Interest Earned	755 56	
Motorcycle Races	1,200 00	
Official Program Advertisements	2,105 00	
Premium List Advertisements	3,150 00	
Rental of Buildings	15,896 50	
Rental of Race Track	4,270 07	
Stall and Pen Fees	1,658 00	
Miscellaneous Revenues (Schedule 6)	1,159 85	
		30,696 08
State of Michigan—Special Appropriation		16,000 00
Total Revenues		$196,408 67

EXPENSES

Administrative Expenses (Schedule 7)	$31,545 45	
Operating Expenses (Schedule 8)	43,287 78	
Departmental Expenses (Schedule 9)	63,906 80	
Interest Payable	15,346 96	
Total Expenses		154,086 99
Profit carried to Surplus Account		$42,321 68

EXHIBIT C

COMPARATIVE STATEMENT OF REVENUES AND EXPENSES

(Condensed)

For the years 1915 and 1916

Revenues:	Year 1915	Year 1916	Increase or Decrease
General Admissions	$64,041 30	$75,700 21	$11,658 91
Auto Races	16,250 95	13,890 11	2,360 84
Concession and Exhibits	33,251 45	39,424 32	6,172 87
Horse Show	2,257 00	4,115 87	1,858 87
Speed Department	14,319 00	16,582 08	2,263 08
Official Program Advertisements	1,730 00	2,105 00	375 00
Premium List Advertisements	2,916 00	3,150 00	234 00
Rental of Buildings	2,724 55	15,896 50	13,171 95
Special Appropriation	16,000 00	16,000 00	....
Sundry Items	7,488 24	9,544 58	2,056 34
Total Revenues	$160,978 49	$196,408 67	$35,430 18

Expenses:			
Administration:			
Advertising	$16,563 22	$15,598 80	$964 42
Office Salaries	2,547 34	4,008 04	1,460 70
Officers' Salaries	5,200 00	6,300 00	1,100 00
Officers' and Directors' Expenses	815 67	1,470 97	655 30
Sundry Items	5,600 72	4,167 64	1,433 08
Total Administrative Expenses	$30,726 95	$31,545 45	$818 50
Operating:			
Attractions	4,589 62	4,334 00	255 62
Fire Insurance	2,201 16	1,952 38	248 78
Fire Works	1,950 00	6,850 00	4,900 00
Labor—General	9,151 03	12,893 82	3,742 79
Liability Insurance	82 40	411 30	328 90
Maintenance of Grounds, Buildings, etc	2,473 14	8,974 63	6,501 49
Sundry Items	5,104 79	7,871 65	2,766 86
Total Operating Expenses	$25,552 14	$43,287 78	$17,735 64
Departmental:			
Auto Races—Prizes and Premiums	7,450 50	5,205 00	2,245 50
Auto Races—Miscellaneous Expense	3,595 41	5,833 23	2,237 82
Better Babies—Prizes and Premiums	119 00	91 17	27 83
Better Babies—Miscellaneous Expense	503 45	611 86	108 41
Boy's State Fair School Expense	1,034 47	1,292 95	258 48
Cattle—Prizes and Premiums	5,179 20	6,783 28	1,604 08
Cattle—Miscellaneous Expense	429 54	288 09	141 45
Dairy—Prizes and Premiums	915 03	757 19	157 84
Dairy—Miscellaneous Expense	726 97	262 53	464 44
Educational—Prizes and Premiums	756 50	673 25	83 25
Educational—Miscellaneous Expense	277 98	700 80	422 82
Farm Products—Prizes and Premiums	1,978 25	2,110 00	131 75
Farm Products—Miscellaneous Expenses	207 21	43 10	164 11
Fine Arts—Prizes and Premiums	257 00	427 00	170 00
Fine Arts—Miscellaneous Expenses	256 00	194 75	61 25
Floricultural—Prizes and Premiums	585 00	545 00	40 00
Horses—Prizes and Premiums	2,312 00	3,724 50	1,412 50
Horses—Miscellaneous Expenses	1,027 92	803 80	224 12
Horticultural—Prizes and Premiums	2,291 50	2,075 05	216 45
Horticultural—Miscellaneous Expenses	230 19	103 60	126 59
Machinery Department Expenses	158 00	93 60	64 40
Needlework—Prizes and Premiums	222 25	335 25	113 00
Needlework—Miscellaneous Expenses	167 00	200 70	33 70
Night Horse Show—Prizes and Premiums	4,305 00	4,560 00	255 00
Night Horse Show—Miscellaneous Expenses	1,168 59	3,365 72	2,197 13
Physical Culture—Prizes and Premiums	259 35	....	259 35
Physical Culture—Miscellaneous Expenses	293 47	978 27	684 80
Poultry—Prizes and Premiums	1,726 50	1,077 50	649 00
Poultry—Miscellaneous Expenses	582 27	581 11	1 16
Sheep—Purses	3,204 60	3,313 50	108 90
Sheep—Miscellaneous Expenses	298 65	290 14	8 51
Speed—Prizes and Premiums	7,670 00	8,450 00	780 00
Speed—Miscellaneous Expenses	5,322 66	4,300 49	1,022 17
Swine—Prizes and Premiums	1,912 60	2,656 75	744 15
Swine—Miscellaneous Expenses	222 50	308 32	85 82
Miscellaneous	1,261 65	869 30	392 35
Total Departmental Expenses	$58,908 21	$63,906 80	$4,998 59
Interest Payable	15,192 93	15,346 96	154 03
Total Expenses	$130,380 23	$154,086 99	$23,706 76
Net Profit	$30,598 26	$42,321 68	$11,904 18

SCHEDULE 1

ACCOUNTS RECEIVABLE

November 30, 1916

Advertisers—Premium List:	
Henry Blackwell & Co	$20 50
Canadian Government Agency	15 00
Melvin E. Case	40 00
Clough & Warren	15 00
Dadco Auto Device Co	25 00
F. B. Drouillard	25 00
The F. B. Ensley Co	9 00
H. & H. Garage & Sales	15 00
Interstate Racing Association	40 00

Advertisers—Premium List:—Con.		
Interurban Hotel	$15 00	
J. D. Kennedy & Co.	25 00	
Movie Operators School	30 00	
Royal Sheet Metal & Heating Co.	25 00	
Royal Valley Coffee Co.	15 00	
A. E. Stevenson	40 00	
Wilcke-Armstrong Co.	15 00	
		$369 50
Advertising—Official Program:		
Gregg Hardware Co.	$60 00	
National Fire Proofing Co.	9 00	
Neal Institute	20 00	
Tire & Auto Service Co.	30 00	
		119 00
Exhibitors:		
Arbuckle-Ryan Co.	$37 00	
Canadian Government Agency	262 00	
Clough & Warren	182 00	
Rosier Bull Tractor Co.	11 00	
Starr Piano Co.	79 00	
Frank P. Miller	51 00	
		622 00
Sundry Accounts:		
American Hampshire Registry Association	$15 00	
American Jersey Cattle Club	70 00	
American Shropshire Registry Association	65 00	
Ann Arbor Buggy Co.	33 75	
Automatic Oil Gas Burner Co.	2 42	
Detroit Driving Club	656 21	
Gaston, Williams & Wigmore	160 50	
Jacob Goldberg	25 00	
A. H. Moone	640 00	
Reo-Mitchell Co.	19 00	
A. G. Roberts	2 00	
Studebaker Corporation	450 00	
		2,138 88
		$3,249 38

SCHEDULE 2

SUSPENSIONS—SPEED DEPARTMENT

November 30, 1916

Year		
1910	J. C. Adams	$250 00
	Geo. W. Baum	70 00
	D. K. Carter	75 00
	Dan Evans	250 00
	John Ferney	50 00
	Fountain Stock Yards	135 00
	John W. Grath	150 00
	James Hogan	250 00
	C. C. Jacobs	50 00
	W. A. Owings	115 00
	A. Raupert	250 00
	T. D. Sheridan	250 00
	W. H. Stubblefield, Jr.	110 00
	Fred Teachout	25 00
1911	J. C. Hickey	50 00
	J. C. Lamar	135 00
	Bascom Parker	500 00
1912	Geo. A. Downer	150 00
	Frank M. Finn	30 00
	Joe Gahagin	390 00
	E. A. Long	225 00
	D. M. Newton	250 00
	W. D. Shutt	600 00
	H. Winterstein	75 00
1913	Bob Carnathan	50 00
	C. L. Lloyd	90 00
	J. E. Gray	811 50
	G. C. Loomis	50 00
	F. C. Stiel	55 00
	C. A. Valentine	104 00
	A. J. Ward	65 00

1914	A. V. Butt	$90 00
	L. D. Burnett, Agent	300 00
	Ed. Gordison	50 00
	Mary L. Graulich	30 00
	S. E. Held	90 00
	Geo. E. Hutton	50 00
	H. H. James	165 00
	W. F. Newby	100 00
	S. A. Proctor	240 00
	Brook Travis	50 00
1915	Dr. D. C. Bell	20 00
	R. L. Cherry	80 00
	Budd Davis	20 00
	Wm. Graves	30 00
	W. H. Harrison	80 00
	E. R. Little	60 00
	W. R. Lyons	35 00
	C. E. Maley, Agent	70 00
	Dr. J. A. Scott	20 00
	Geo. Wheeler	50 00
	J. W. Woods	50 00
1916	N. C. McKinsey	30 00
	Carl Rooks	30 00
	D. T. Hopkins	30 00
	Dempsey Brothers	30 00
	H. Rutherford	30 00
	H. M. Hoffman	30 00
	J. M. McMeekin	60 00
	Thos. Halloway	60 00
	C. S. Bigler	30 00
	H. J. Purdum	30 00
	Wm. Proper	60 00
	Horace Markham	60 00
	W. W. Hill	60 00
	H. S. German	30 00
		$7,910 50

SCHEDULE 3

COMPARATIVE STATEMENT OF PLANT ACCOUNTS

1914 and 1915

	Book Value Nov. 30, 1915	Additions Year 1916	Book Value Nov. 30, 1916
Land and Improvements:			
Fences	$4,259 63		$4,259 63
Land	208,912 50		208,912 50
Race Track	29,631 72		29,631 72
Race Track Drain	98 55		98 55
Roads and Drives	10,308 95	$1,500 00	11,808 95
Shrubs and Trees	....	401 20	401 20
Sidewalks	10,458 89	504 66	10,963 55
Water System and Sewage	21,434 68		21,434 68
	$285,104 92	$2,405 86	$287,510 78
Buildings:			
Agricultural Building	15,675 00		15,675 00
Arcade Building	201 40		201 40
Art Building	....	5,634 68	5,634 68
Auto Building	37,039 59		37,039 59
Band Stand	2,125 00		2,125 00
Bleachers	1,800 00		1,800 00
Cattle Barns	13,500 00		13,500 00
Closets	15,375 00		15,375 00
Dairy Building	14,669 89	241 87	14,911 76
Superintendent's Dwelling	278 06	3,721 94	4,000 00
Educational Building	5,850 00		5,850 00
Entrances	....	4,859 62	4,859 62
Fire Building	1,000 00		1,000 00
Grand Stand	57,460 78		57,460 78
Horse Barns	29,936 53		29,936 53
Horticultural Building	15,734 22		15,734 22
Machinery Building	12,774 07	1,000 00	13,774 07
Main Building	29,587 18		29,587 18
Michigan Building	14,446 96	147 00	14,593 96
Poultry Building	3,150 00		3,150 00
Sheep Barns	8,505 00		8,505 00
Speed Barns	25,896 70	354 21	26,250 91
Swine Barns	9,405 00		9,405 00
Tool House	1,800 00		1,800 00
Woman's Building	....	20,000 00	20,000 00
Total	$316,210 38	$35,959 32	$352,169 70

Equipment:			
Dairy Building Equipment	$22 68		$22 68
Electric Plant and Equipment	19,902 92	$2,004 76	21,907 68
Engine and Pump	1,006 50		1,006 50
Grand Stand Awnings	27 00		27 00
Horses, Harness, Wagons and Autos	473 00	350 50	823 50
Incinerator	12 83		12 83
Lawn Seats	192 46	264 42	456 88
Mattresses and Cots	288 00		288 00
Needlework and Equipment	30 00		30 00
Night Horse Show Equipment	115 00		115 00
Fair Ground Furniture	....	213 70	213 70
Office Furniture and Fixtures	1,281 49	384 25	1,665 74
Poultry Coops	1,242 10	130 90	1,373 00
Race Track Tarpaulin	....	1,200 00	1,200 00
Signal Flags	12 50		12 50
Tools and Equipment	927 39	414 95	1,342 34
Turnstiles	3,450 73		3,450 73
Total	$28,984 60	$4,963 48	$33,948 08

RECAPITULATION

Land	285,104 92	2,405 86	287,510 78
Buildings	316,210 38	35,959 32	352,169 70
Tools and Equipment	28,984 60	4,963 48	33,948 08
Totals	$630,299 90	$13,328 66	$673,628 56

SCHEDULE 4

SUNDRY ACCOUNTS PAYABLE

November 30, 1916

Burroughs Adding Machine Company	$52 00
Maxwell Motor Company	350 00
Royal Sheet Metal Company	142 50
Highland Park Paint & Glass Company	25 00
Walker & Company	105 00
Pontiac Paint Manufacturing Company	534 40
Frank Farrington Company	163 60
Lee Hardware Company	298 35
Standard Oil Company	14 50
Royal Oak Ice & Produce Co	16 65
Detroit Edison Company	3 49
Highland Park Water Works	1,273 43
A. W. Ehrman & Company	50 00
Total	$3,028 92

SCHEDULE 5

Deposits on 1917 Contracts

November 30, 1916

Otto Wendell	$100 00
Goodyear Raincoat Company	100 00
Shuler & Hotchkiss	200 00
E. T. Franklin	50 00
Louis Gordon	100 00
Total	$550 00

SCHEDULE 6

MISCELLANEOUS REVENUES

November 30, 1916

Sale of Scrap Platinum	$31 83
Teaming	261 56
Physical Educational Fees	22 25
Baby Check Room Receipts	59 55
Incubator Baby Receipts	202 65

Dog Show Receipts	$69 31
Sale of Melons	135 59
Sale of Programs	92 22
Net Income—Sale of Cattle	81 36
Sale of Waste Paper	17 54
Miscellaneous Items	185 99
Total	$1,159 85

SCHEDULE 7

ADMINISTRATIVE EXPENSES

November 30, 1916

Advertising—Bill Boards, Posters, etc	$2,529 10
Advertising—Miscellaneous	2,051 68
Advertising—Newspaper and Magazine	5,887 24
Advertising—Official Program Expense	1,274 70
Advertising—Premium List Expense Including Postage	1,802 21
Advertising—Publicity Agents Fees	1,364 79
Advertising—Street Car Advertising	689 08
Bad Debts	146 00
Bookkeeping and Auditing	801 25
Commission on Sale of Bonds	318 50
Legal Expense	50 00
Membership	331 00
Office Rent	750 00
Office Salaries	4,008 04
Office Supplies and Expense	764 95
Officers' Salaries	6,300 00
Officers' and Directors' Expense	1,470 97
Postage	468 70
Special Expense (Schedule 7A)	342 01
Telephone and Telegraph	195 23
Total	$31,545 45

SCHEDULE 7A

SPECIAL EXPENSES

November 30, 1916

Bond Expense	$150 00
Booklet of Audit	72 90
Flowers for Bob Burman	10 35
Expenses W. D. Edenburn at Milwaukee Race Meet	50 00
Dental Work—Mrs. M. T. Woodruff	25 00
Automobile Guide	25 00
Miscellaneous Items	8 76
Total	$342 01

SCHEDULE 8

OPERATING EXPENSES

November 30, 1916

Attractions	$4,334 00
Auto Expense	457 54
Decorations	194 60
Fire Insurance	1,952 38
Fire Protection	391 25
Fireworks	6,850 00
Freight, Express and Cartage	193 82
Labor—General	12,893 82
Liability Insurance	411 30
Light and Fuel	1,040 44
Maintenance of Land, Buildings and Equipment	5,411 63
Miscellaneous Operating Expenses (Schedule 8A)	1,185 91
Police Protection	1,230 00
Repairs to Electrical Plant	3,563 00

Ribbons, Badges and Buttons	$536 50
Supplies for Grounds	1,829 49
Rental of Tents, Awnings, etc	100 80
Water Rates	711 30
Total	$43,287 78

SCHEDULE 8A

MISCELLANEOUS OPERATING EXPENSES

November 30, 1916

Miscellaneous Printing	$735 73
Expense on Sale of Melons	150 00
Restoring Statue of Laocoon	14 25
White Duck Caps	15 00
Garden Seeds	21 25
Blue Prints	38 90
Bird Houses	62 50
Other Sundry Items	148 28
Total	$1,185 91

SCHEDULE 9

DEPARTMENTAL EXPENSES

November 30, 1916

Auto Races:			
Prizes and Premiums:			
Ford Races, July 4	$505 00		
Ford Races, Sept. 10	500 00		
Total		$1,005 00	
Entertainment:			
Auto Races, May 28-30	$128 00		
Auto Races, June 4	42 00		
Ford Races, July 4	114 00		
Ford Races, Sept. 10	686 00		
Auto Races, Sept. 11-12	1,372 00		
Total		2,342 00	
Grand Stand Labor:			
Auto Races, May 28-30	$30 00		
Auto Races, June 4	30 00		
Ford Races, July 4	52 00		
Ford Races, Sept. 10	94 00		
Auto Races, Sept. 11-12	188 00		
Total		394 00	
Miscellaneous Expenses:			
Auto Races, May 28-30	$1,727 11		
Auto Races, June 4	478 21		
Ford Races, July 4	741 91		
Auto Races, Sept. 10, 11, 12	4,350 00	7,297 23	
Total			$11,038 23
Better Babies:			
Prizes and Premiums		$91 17	
Judging		270 00	
Miscellaneous Expenses		341 86	
Total			703 03
Boys' State Fair School Expense			1,292 95
Cattle:			
Prizes and Premiums		$6,783 28	
Judging		158 55	
Miscellaneous Expenses		129 54	
Total			7,071 37

Dairy:		
Prizes and Premiums	$757 19	
Judging	77 15	
Miscellaneous Expenses	185 38	
Total		$1,019 72
Educational:		
Prizes and Premiums	$673 25	
Judging	35 00	
Miscellaneous Expenses	665 80	
Total		1,374 05
Farm Products:		
Prizes and Premiums	$2,110 00	
Judging	43 10	
Total		2,153 10
Fine Arts:		
Prizes and Premiums	$427 00	
Judging	45 00	
Miscellaneous Expenses	149 75	
Total		621 75
Floricultural:		
Prizes and Premiums		545 00
Horses:		
Prizes and Premiums	$3,724 50	
Judging	182 50	
Miscellaneous	621 30	
Total		4,528 30
Horticultural:		
Prizes and Premiums	$2,075 05	
Judging	24 60	
Miscellaneous Expenses	79 00	
Total		2,178 65
Machinery Department Expense		93 60
Needlework:		
Prizes and Premiums	$335 25	
Judging	30 00	
Miscellaneous	170 70	
Total		535 95
Night Horse Show:		
Prizes and Premiums	$4,560 00	
Entertainment	2,059 00	
Judging	182 50	
Grand Stand Labor	490 00	
Miscellaneous Expenses	634 22	
Total		7,925 72
Physical Culture:		
Miscellaneous Expenses		978 27
Poultry:		
Prizes and Premiums	$1,077 50	
Judging	120 00	
Miscellaneous Expenses	461 11	
Total		1,658 61
Sheep:		
Prizes and Premiums	$3,313 50	
Judging	50 68	
Miscellaneous Expenses	239 46	
Total		3,603 64
Speed Department:		
Purses	$8,450 00	
Advertising	218 20	
Entertainment	2,058 00	
Grand Stand Labor	576 00	
Judging	145 00	
Membership Dues	125 00	
Printing	76 92	

Speed Department:—Con.		
Secretary's Salary	$500 00	
Sundry Salaries	386 57	
Miscellaneous Expenses	214 80	
Total		$12,750 49
Swine:		
Prizes and Premiums	$2,656 75	
Judging	72 00	
Miscellaneous Expenses	236 32	
Total		2,965 07
Miscellaneous Prizes:		
Trophy Cups		869 30
Total		$63,906 80

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